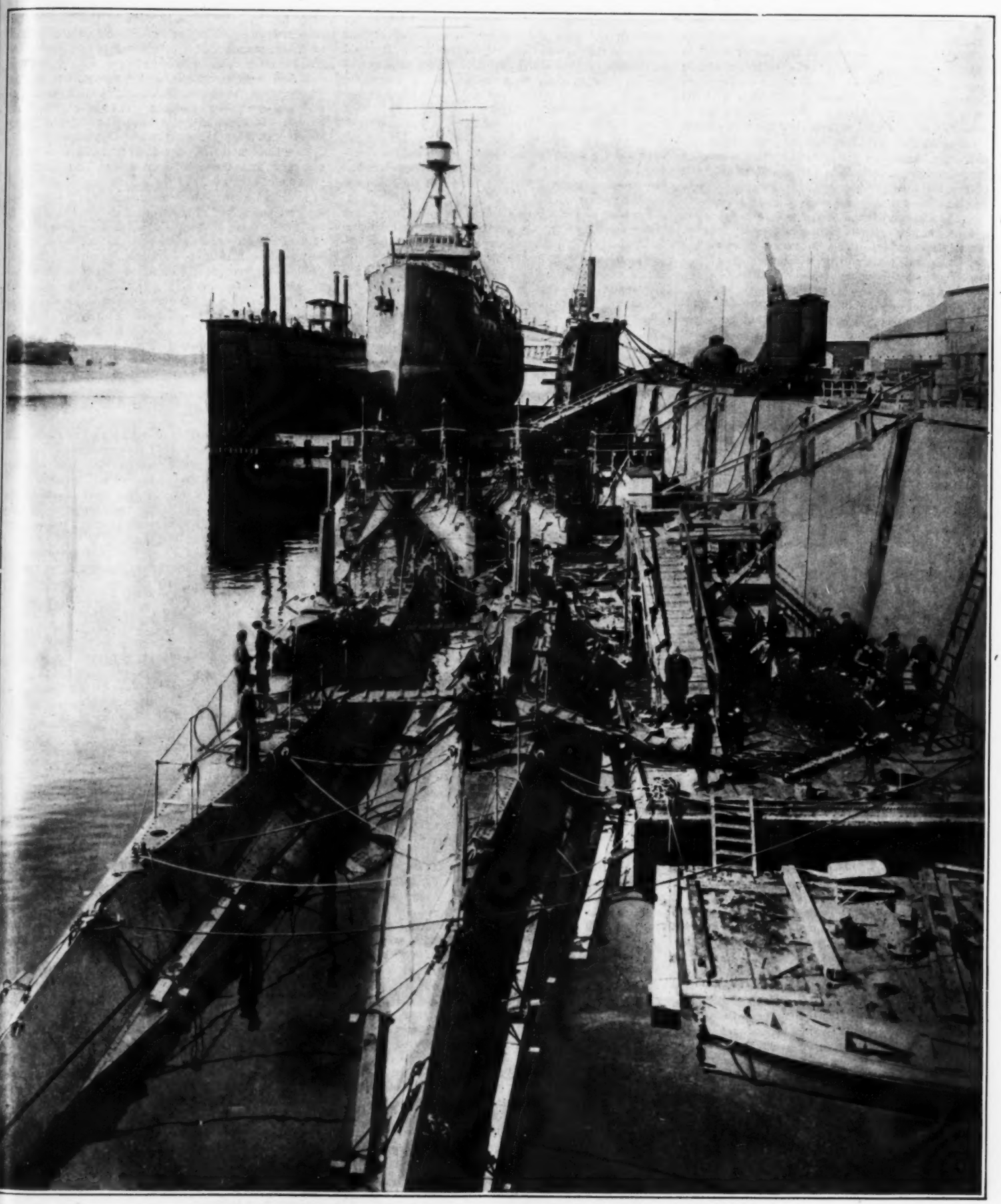
SCIENTIFIC AMERICAN SUPPLEMENT

Copyright 1915 by Munn & Co., Inc.

VOLUME LXXX
NUMBER 2079

NEW YORK, NOVEMBER 6, 1915

10 CENTS A COPY
$5.00 A YEAR



Five submarines of American design for the British navy at the builders yard in Canada.

SUBMARINES THAT CROSSED THE OCEAN.—[See page 293.]

Weights of Elements*

The Fundamental Principles Underlying the Choice of Standard Weights for the Elements

By John Waddell, B.Sc., (London), D.Sc. (Edinburgh)

STUDENTS of chemistry, even after having worked at the subject for two or three years, often show the crudest and most vague ideas regarding the principles upon which rest the standard members for the different elements—the so-called atomic weights. Probably nine out of ten of them, if given the percentage composition of several compounds of two elements and asked to show that these compounds conform to the law of multiple proportion, will make use of the ordinary atomic weights in the proof. If the names of the elements are not given, the data are considered insufficient and the problem is unsolved. It is not realized that the law is a *statement* of a *fact* of *nature*, that the fact existed long before its discovery, and that the proof of the fact cannot depend upon any *arbitrary* value that we assign to the elements. Indeed, it is vaguely, if at all, realized that the numbers are arbitrary. Many students think that Cl = 35.5 or Na = 23 is as much a property of the substance as that the former is a yellowish green gas of very irritating action of the mucous membranes, or the latter is a brilliant white metal lighter than water. It is with a view of helping students, and possibly teachers also, that this article is written.

The student learns that there are so-called chemical laws, the law of constant proportions, of multiple proportions, and of reciprocal proportions; but he learns them as isolated statements, and has no conception of their bearing upon the science of chemistry and of chemical theory.

It should be noted, in the first place, that if the law of constant proportions did not hold, no calculation of chemical quantities would be possible. If one specimen of common salt contained one third its weight of chlorine, another one half, another one fifth, or any haphazard amount, it is evident that the manufacturer would not know how much salt he would need in order to make a ton of chlorine. It is also evident that if a definite quantity of sodium, such as a gramme or an ounce, were taken as a standard and represented by a symbol which might be a square, or a cube, or a sphere, or a letter, it would be impossible to represent a standard quantity of chlorine, since there is *no* standard quantity, the quantity of chlorine combining with the standard quantity of sodium varying in a fortuitous manner.

So, also, if water contained at one time eight, at another nine, at another ten times as much oxygen as hydrogen, it would be impossible to fix on *standard* quantities for *both* oxygen and hydrogen. If, then, the law of constant proportion did not hold, it would be impossible for us to have a set of standard quantities for the different elements.

But if the law of reciprocal proportions (sometimes called the law of combining weights) did not hold, it would be equally impossible to compile a set of standard weights for the elements. Suppose, for instance, that one part by weight of hydrogen unites with seven parts by weight of oxygen and with thirty parts by weight of chlorine, but that thirty parts of chlorine unite not with *seven* but with *nine* parts of oxygen; it is evident that though the standards for hydrogen and chlorine may be taken as unity and thirty, there is no standard possible for oxygen. Seven and nine would have equal claims, and the more numerous the compounds of oxygen examined, the greater might be the confusion.

If the law did not hold it would not be possible, by knowing how one element united with each of two others, to predict how these two elements would themselves unite. An illustration is afforded by the case of alcohol, water, and ether. Alcohol mixes in all proportions with water, and in all proportions with ether, but ether and water are far from mixing in all proportions. Water will dissolve a little ether and ether will dissolve a little water, the quantity dissolved by an equal amount of solvent being different in each case. A universe is conceivable where there would be no law of constant or of reciprocal proportions, and if such a universe were made up of different elements it would be impossible to have symbols as we now do for the elements.

It is because these laws are found to hold that the atomic theory is possible. Indeed, if there are two atoms in the usually accepted sense the laws must hold. The converse is not necessary. It does not follow that because the laws are a correct statement of fact atoms must necessarily exist, any more than it would follow that because two solutions look alike and can neutralize an acid they necessarily contain the same substance in solution.

* *Chemical News.*

But now, assuming the laws, how do we arrive at standard numbers for the elements?

The law of constant proportions refers to weight; *four grammes* of sulphur unite with *seven grammes* of iron. Shall we make the standard weight of sulphur 4 grammes and the standard weight of iron 7 grammes? Or shall we make the standard quantity of sulphur unity and the standard quantity of iron 1.75? It would be possible to make either choice, and since sulphur and oxygen unite in equal quantities the standard quantity of oxygen would be four, or unity, according to the choice that we make.

On the other hand, the quantity of *iron* might be called unity, in which case the standard number for sulphur and for oxygen would be 4/7. So we see the standard numbers will depend upon the element we choose as the primary standard and the value we assign to the standard quantity of it.

But now we are confronted with the question whether either sulphur or iron is the best element to choose as the primary standard. If we consider first what elements are obviously unsuitable, it may be more easy to decide what are suitable. Obviously the very rare elements, such as radium, scandium, or praseodymium, are unsuitable because of their rarity and cost, if for no other reason. Obviously, also, any member of the argon group of elements is unsuitable, if for no other reason, because they do not form compounds with other elements. It is plain, then, that the element chosen as original standard must be plentiful and must form compounds with a number of other elements. It should also be possible to obtain it practically pure. The elements that form water have these characteristics, and these elements hydrogen and oxygen have both been chosen as the standard. Hydrogen has the advantage that it enters into combination in the smallest quantity of any of the elements, and so if the standard quantity of it is taken as unity the standard quantities of all the other elements will be greater than unity. Oxygen has the advantage that it combines with more elements than does hydrogen, forming compounds with nearly all the elements. Dalton chose to make hydrogen the standard. Berzelius made oxygen the standard. The value given to hydrogen was naturally unity, Berzelius chose to call the standard quantity of oxygen 100. Since the quantity of oxygen in water is approximately eight times the quantity of hydrogen, if oxygen is taken as 100, hydrogen is approximately 12.5, and the number in the list of standard quantities for the different elements, according to Berzelius's plan of making the standard quantity of oxygen 100, would be 12.5 times as great as those determined upon Dalton's basis. The standard of hydrogen equal to unity was considered most convenient and was generally adopted.

Now, if hydrogen were taken as unity, and if hydrogen formed one compound and only one with every element, it would, theoretically at least, be very easy to determine numbers for the standard quantities of each of the other elements, it being understood that the law of *reciprocal* proportions holds good. But the fact is that hydrogen does not form compounds with all the other elements, and with many elements it forms more than one compound. The first difficulty can be got over. The standard quantity of calcium, for instance, could be arrived at if the quantity of oxygen which unites with unit quantity of hydrogen is known and the quantity of calcium with which this quantity of oxygen will unite. Suppose eight parts of oxygen unite with one part of hydrogen, and eight parts of oxygen unite with twenty parts of calcium, the standard quantity of calcium is evidently 20.

A still greater difficulty is caused by the fact that elements frequently combine in more than one ratio, forming more than one compound. Hydrogen, for example, unites with sixteen times its weight of oxygen as well as with eight times its weight. Should the standard quantity of oxygen be 8 or 16? This question caused difficulty for a long time, and so long as *weights only* were considered the problem was unsolvable.

Solids and liquids have no definite and *general* relationship between their weight and volume, but gases have, and so our formulæ for gases can be made to represent volumes as well as weights, and if our standard numbers for weight can be suitably fitted to volumes a decided advance may be made. Assuming that 1 gramme of hydrogen has been taken as standard weight, and is represented by some symbol, such as H, a very natural volume to choose as the fundamental standard would be the volume of 1 gramme of hydrogen, which at the normal temperature and pressure is approximately 11.2 liters. Now, if H is the standard quantity, the standard quantities of all gases containing hydrogen must have a certain number of these standard quantities of hydrogen, one or two, or three or four, etc., H. If 11.2 liters is to be the standard volume, 11.2 liters of all gaseous compounds of hydrogen should contain 1, 2, 3, or 4, etc., grammes of hydrogen. This turns out to be true for many compounds of hydrogen, such as sulphureted hydrogen, marsh-gas, and ethylene, but not for phosphureted hydrogen, ammonia, and hydrobromic acid, and a number of others. If, however, 22.4 liters be taken as the standard volume, the difficulty disappears; 22.4 liters of ammonia and of phosphureted hydrogen have in their composition 3 grammes of hydrogen, and 22.4 liters of hydrobromic acid contain 1 gramme of hydrogen, and there is no gaseous compound of hydrogen known which has not in that volume some integral number of grammes of hydrogen; that is, the standard *volume* of the gas contains some integral multiple of the standard *weight* of hydrogen. Now, if this same volume, 22.4 liters, be chosen for the gaseous compounds of oxygen, it will be found that the oxygen contained is always some multiple of 16. In the same way 22.4 liters of gaseous nitrogen compounds contain some integral multiple of 14 grammes of nitrogen.

Now, the point to be decided regarding the standard of oxygen was whether it should be 8 or 16, because these are the ratios in which it combines with the unit weight of hydrogen. In the same way the question regarding nitrogen was whether it should be 14 or some multiple or submultiple of 14. It will be seen that the experiments with gases give the preference to 16 and 14 as the standard quantities of oxygen and nitrogen. The same reasoning applies to all those elements that give gaseous compounds easily worked with, and so their most satisfactory standard numbers are deduced.

If 100 grammes of oxygen had been taken as the standard weight of that element, the volume would have been different, namely, 6.25 times as great, but the reasoning would be exactly the same.

It has been assumed up to now that the weight of oxygen in water is exactly eight times that of the hydrogen. This is not exactly the case, but more nearly 7.94 times as much, and if the standard weight of hydrogen is taken as unity the standard weight of oxygen would be not 16 but 15.88 nearly. Now, many more elements combine with oxygen than with hydrogen, and the ratio of the element to oxygen is more often determined than the ratio to hydrogen, and if the number assigned to the element is to be compared with hydrogen as unity, it is evident that the ratio to oxygen must be multiplied by 15.88. If there is any error in the ratio of oxygen to hydrogen, this error would appear in the other elements being greater, as the standard number is greater, so that in the case of uranium the oxygen error would be multiplied by 15. Hence, it is now usual to make oxygen the standard, but instead of 100, as selected by Berzelius, the standard quantity is taken as 16. This gives the standard quantity of hydrogen as 1.0075 instead of unity. This small difference does not usually need to be considered. One advantage of taking the standard quantity of oxygen as 16 is that the standard quantities of most of the other elements are sufficiently near whole numbers that these whole numbers may for most purposes be taken as exact. It is to be clearly understood that making the standard quantity of oxygen 16 arose from making the standard quantity of hydrogen unity. No one would naturally have chosen 16 as the standard quantity of oxygen in the first instance.

It may be asked whether the law of Dulong and Petit does not give our present atomic weights—does not decide, for instance, whether the standard quantity for iron shall not be 56 instead of 28 or 7, as was suggested early in this article. Would not Dulong and Petit's law preclude oxygen being taken as 100 and the standard of iron 350? The reply is, not at all! Dulong and Petit's law is often given in the form that the product of the atomic weight multiplied by the specific heat of an element is approximately 6.4. This, however, is not really the law. With the set of standard weghts that we have adopted for the different elements the product of these standard weights and the specific heats is approximately 6.4, and if any new element were discovered and its specific heat determined, the number which would be chosen for the standard weight would be that which multiplied by the specific heat would most nearly approach 6.4. But this is because we have already fixed

upon the standard weights for the other elements. If all the other standard weights were half their present value the product would be 3.2; if they were double, the product would be 12.8. All that Dulong and Petit's law asserts is, that the standard weights of all the elements shall be so chosen that the product of the standard weight into the specific heat will be approximately constant. All the standard weights must conform; the product in all cases may (so far as *this* law is concerned) be 3.2 or 6.4, or 17 or 100, or any other number, but it is not allowable for the product to be in one case 3.2, in another 6.4, in another 17 or 19, or 100.

The Periodic Law would also be unaffected if the value assigned to the primary standard, provided the *ratio* between the standard weights is kept the same as now. The Periodic Law would be interfered with if calcium were given a value 20 while potassium was kept at 39, but if the value of potassium were halved or doubled the Periodic Law would be undisturbed, provided the present numbers for all the other elements were correspondingly halved or doubled.

The line of argument presented above is not difficult to follow if the student's mind is not prejudiced by wrong impressions already received or misconceptions already formed. This treatment of the subject should be introduced before the atomic theory, but not till some familiarity is obtained with simple experimental phenomena. Water, hydrogen, oxygen, hydrogen peroxide, ozone, air, nitrogen, ammonia, nitrous oxide, nitric oxide, carbon dioxide, and carbon monoxide may well be experimented with and their properties discussed as a beginning in the study of chemistry. Incidentally, the difference between a mixture and a compound will be noticed, and facts may be learned which may be used to lead up to the laws of chemical combination and hence to formulæ. In order to change the symbol weight of an element to atomic, it is only necessary to introduce the atomic theory, and Avogadro's law will allow the standard formulæ for gases to be translated into *molecular* formulæ. The student should be made to thoroughly realize that Avogadro's law is not a law in the same sense as the laws of constant, multiple and reciprocal proportions, but that they are statements of fact, while it is merely the statement of a theory; a theory, indeed, in accordance with all the facts so far as known.

Accuracy of Fire

The Principal Causes Affecting the Fire of Big Guns

In an article in *The Engineer*, Capt. H. J. Jones, Inspector of Ordnance Machinery of the British Army, discusses the factors affecting the accuracy of fire and range of big guns, and gives some causes that will explain the apparent haphazard shell fire that we read of in the reports from the war, and why the shots from big guns so frequently miss their mark.

BALANCED--ERRORS.

(1) *Whip.*—The whip or transverse vibration of the muzzle portion of long guns may be the source of very large errors. It becomes pronounced with 50-caliber guns, particularly if they lack girder stiffness. The droop of a 12-inch 50-caliber gun is from 0.3 inch to 0.4 inch, and its cantilever stiffness such that it makes from 130 to 150 complete vibrations per second. The velocity of the center of the muzzle across the line of departure arising from this vibration may be as high as 50 feet per second with wire-wound guns. Assuming the mean velocity along the rifling to be about 1,800 feet per second, we see that there will be about three complete vibrations of the muzzle while the projectile is in the gun. The projectile may leave the bore with the center of the muzzle in any position between its limits of vibrational displacement, and the error in the angle of departure is thus quite indeterminate and fortuitous, and the error of range symmetrically disposed about the mean.

(2) *Firing Interval.*—This is the interval between the layer pressing the trigger and the projectile leaving the bore. With moving gun platforms it is the main cause of inaccurate shooting. The firing interval is made up of two parts, one, from 0.08 to 0.13 second, during which time the tube is fired, the charge ignited and the band engraved, and the other, from 0.022 to 0.035 second, representing the time of travel of the projectile along the rifling. In other words, the firing interval for a modern 12-inch is, on the average, about 0.122 second. These figures, however, may be greatly exceeded with defective tubes and firing arrangements.

Modern battleships have a metacentric height of from 3.5 feet to 4.5 feet and a period of about 8 seconds for a single roll of 5 degrees. This is equivalent to a maximum angular velocity of 15 minutes of angle per 0.10 second. Hence, if we assume that the layer does not alter the elevation between the instant of pressing the trigger and the projectile leaving the bore, the average firing interval means a possible error with the 12-inch of 16.3 minutes elevation. Since 1 minute alteration of elevation at 10,000 yards corresponds to about 15 to 20 yards on the water, we see that, due to a moderate roll of 5 degrees, every round may be a miss, although the marksmanship of the layer be perfect. Under such conditions, firing for individual hits is the merest futility; firing by salvo becomes imperative.

(3) *Air Spacing.*—When using reduced charges a considerable space exists between the end of the charge and the base of the shell. Wave pressures are likely to be set up, giving rise to irregular burning and irregular muzzle velocity.

(4) *Propellant.*—The acceptance limits of a lot of new powder define the probable variation of muzzle velocity from round to round. These limits become extended when lots of varying ages of different makes are in use, and speaking generally, the mean velocity from any one lot shows a progressive fall with age.

(5) *Projectile.*—Those qualities of projectiles which affect the ballistic coefficient—size, weight, balance, etc.—will vary from round to round. The limits of variation are determined mainly by questions of expense in manufacture and inspection.

(6) *Steadiness.*—The coefficient of steadiness is affected by the position of the driving band, the position of the center of gravity with relation to the center of form, the speed of rotation, initial centering, and the actual gun elevation. Projectiles in the descending branch of high-angle trajectories become increasingly unstable as the elevation is increased.

SYSTEMATICALLY LOADED ERRORS.

(1) *Laying.*—As a rule, layers have a personal prejudice for laying either high or low, and in a bad light, in rain and mist, or when fatigued, excited or impatient, they tend to exaggerate their specific defect. All laying depends on the personal judgment of the layer—the attainment of a state of mental satisfaction, in which a condition of equilibrium is established between the feeling that "that is near enough," and the adjustment of muscular effort required to make it nearer. Most heavy guns are more easily depressed than elevated, and when following a target in a seaway the gun tends to take charge in depression and is a very fatiguing mass to control in elevation. When laying by clinometer, if the bubble be very lively, the layer becomes impatient, whereas if the bubble be sluggish the error of elevation depends on whether the last motion of setting be in elevation or depression.

(2) *Jump.*—Jump is very considerable with field carriages on bad ground, and in the case of naval mountings varies not only with the same mounting in different parts of the ship, but also when the gun is trained on different bearings. Mountings carried on a pedestal with a ball race of small diameter, particularly if they are balanced mountings, are extremely unstable, the jump varying between positive and negative limits of as much as half a degree. Errors of elevation with these mountings are also caused by the movements of the gun members on the platform and by the tilting of the mounting by the thrust at the elevating arc. With hydro-pneumatic mountings the recoil and angle of departure are greatly affected by the mere rate of fire, the frothing of the liquid and the liberation of air being dependent on the time interval of rest between the rounds.

(3) *Dials.*—The dials are graduated from a calculated range table that has been correlated to the shooting of one or more guns of the particular nature. Any individual gun, however, may range consistently short or over, due to some peculiarity not possible to define.

(4) *Instruments.*—There are a considerable number of instrumental errors which arise mainly from imperfect adjustment, such as telescopes out of collimation, displacement of the zero reading of dials, range-finders out of level or incorrectly datumed, tide gages incorrectly set, etc., that give a permanently loaded error to the shooting of the gun.

UNBALANCED ERRORS.

(1) *Droop.*—This is caused by the heat strains of unequal cooling during manufacture or by a lack of girder stiffness. In both cases perceptible modifications of the droop are brought about during firing or by the heating effect of mere sunshine. Cases have been met where the bend of field guns is beyond the condemning limit when measured in the gun park, but four or five minutes less after the guns had been heated by exposure to a tropical heat for three hours.

(2) *Choke and Metallic Fouling.*—The effect of choke and metallic fouling is not only to increase bore resistance and thus cause variable muzzle velocities, but also to make one gun differ from another of the same nature at the same period of its life. The effect depends on whether the choke or coppering occurs in such a position that the rate of burning of the charge is affected by lowering the normal rate of expansion of the bore gases. Heavy guns which copper rapidly may lose as much as 50 yards per round at 5,000 yards.

(3) *Driving Band.*—When projectiles are fired for recovery their driving bands are found to be fanned, eccentric, worn smooth or multiply engraved. This irregular action implies variable engraving and rifling resistance, and, in consequence, variable muzzle velocity. In addition, with long shell or with a gun eroded at the commencement of the rifling oblique loading results, and heavy groove marking on the body of the shell itself.

(4) *Wear and Windage.*—Wear at the commencement of the rifling gives rise to over-ramming and to an engraving resistance less than that normal for a new gun. Heavy guns have a rapid rate of wear and rapid rate of fall of muzzle velocity for about the first eighty rounds of their life, a feature that is not exhibited by guns below about 5-inch caliber, these latter having a gently diminishing rate of fall of muzzle velocity throughout their life. General wear of the bore gives rise to gas escape, fusing of the driving band, irregular rotation and a fall of muzzle velocity.

(5) *Wet Chamber.*—This is a fruitful cause of lack of agreement between performance and intention. When charges are burning in a gun the principal mode of heat loss to the walls is by radiation. The magnitude of this heat loss is not generally appreciated, although it is of the order of 10 per cent of the total heat of combustion. The most important practical fact to remember, however, is that the rate of absorption of radiant heat greatly depends on the mere condition of the surface, differences of polish or of wetness hardly perceptible to the eye causing a considerable change in the rate of heat transfer. Water in the chamber affects the ballistics in two ways. Water being opaque to radiant heat reduces the initial heat loss to the walls by radiation, and water left in the chamber after sponging out absorbs heat on being converted into steam. The initial greasiness of the gun, in its effect on radiation, may explain the "mystery" of the first round. The quantity of water left in the chamber depends largely on the drill, and also on the shape of the chamber and the elevation of the gun. Quick-firing guns with fixed ammunition are not liable to this source of error.

(6) *Ramming.*—Just as an over-rammed projectile causes a loss of muzzle velocity, so also does the slipping back of a projectile cause a rise of muzzle velocity. A 6-inch shell, slipping back 6 inches, may be expected to give a maximum pressure of 1.5 ton above the normal and an increase of muzzle velocity of about 60 feet per second.

(7) *External Ballistics.*—The general external ballistic conditions, particularly the extent, direction and speed of gusts of wind, are quite indeterminate, and the errors of direction and range to which they give rise are entirely beyond prediction.

New Types of Films

An insulating skin on aluminium, so thin and flexible as to make small aluminium wire as economical of space in coils as copper, has been developed by C. E. Skinner and L. W. Chubb of the Westinghouse Electric and Manufacturing Company, of Pittsburgh, and was described in a recent paper presented before the American Electrochemical Society. By different processes two types of films are produced. One is smooth and iridescent and the other white and abrasive. The latter is the better, being from 0.0001 to 0.0004 inch thick and standing from 200 to 500 volts. Two wires can be pressed together so as to indent without breaking the film; but if there is relative motion the abrasiveness of the film will expose the metal for a short circuit. The material is fireproof and has mechanical strength to support the wire in small coils above the melting point. The film is made by passing the wire through electrolytic baths (solutions of borax, ammonium borate or sodium silicate), the wire being the anode.

Some Aids to Designing*

Proportioning the Machine to the Size of the Man

It is always convenient, sometimes very necessary, when designing machinery, to be able to judge the size and appearance of the machine in relation to a man. Especially is this so in connection with things which have to be operated, or controlled, by living operators, such as machine-tools, motor-cars, windlasses, etc. It is not always possible to make full-size drawings, and even when it is, one cannot accurately judge positions from them without sketching the figure in its place. A device I have used for some time with great success is a

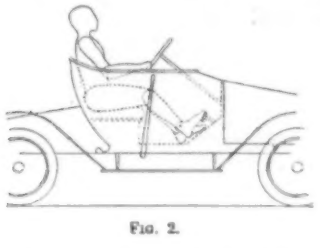


Fig. 2.

flat, jointed figure, made to scale from thin sheet celluloid, as shown in Fig. 1. With this laid upon a drawing one can see at a glance if the various levers, and other controls, are in convenient positions. For example, in Fig. 2 we see the application of the figure to a motor car, showing that the steering wheel and brake pedal are in their right places, the brake and gear levers comfortably

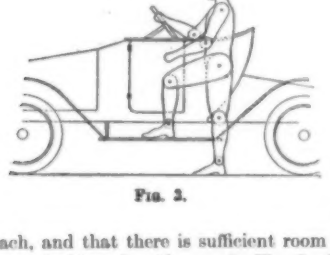


Fig. 3.

within reach, and that there is sufficient room between the seat and dashboard. Also, as in Fig. 3, the figure standing beside the car gives a very good idea of its size, and indicates that the step is about the right height from the ground, and the car would be easy to get into.

Personally I find that a figure made to a scale of 1½ inch to the foot (one eight full size) is the most useful for motorcar drawings; but it is a good plan to have several different sizes to suit the work usually dealt with. The figures are easy to make, and the material may be varied. Stiff Bristol card can be used; but the joints are rather apt to give way. Celluloid or vulcanite are the best, and a broken photographic developing dish can be usefully employed. Fig. 4 gives the sizes of the various pieces, the squares enabling them to be readily enlarged to any desired size. Each square represents an inch of a (full size) man of 5 feet 10 inches in height. For shorter figures the dimensions can be modified accordingly. Measuring one's own limbs is as good a method as any for arriving at the sizes.

When the separate pieces have been drawn on paper, they are cut out and used as templates to mark round upon the celluloid with a fine-pointed pencil. Cut carefully around the outlines with a fretsaw, and trim up the edges with a smooth file and fine glasspaper. Drill

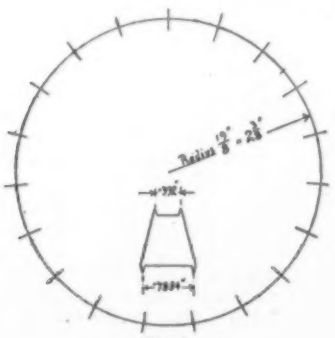


Fig. 6.

the rivet holes to fit 1/16-inch copper wire, slightly countersinking them on the sides where the rivet heads are formed. Use short pieces of soft copper wire for rivets, and do not hammer them up too tightly. The joints should just move smoothly and remain where placed without being too stiff. Keep the rivet heads as flat as possible. If more than one size of figure is made, mark each with its scale.

The larger pieces of celluloid left over from the above can be usefully employed for templates of gear teeth; and they will be found to save a lot of time when many teeth have to be shown on a drawing. The best and

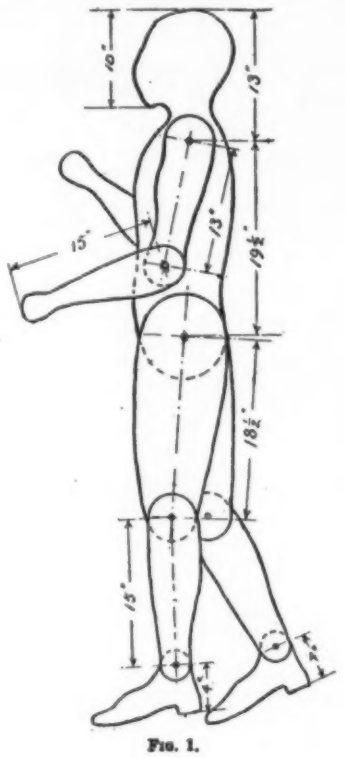


Fig. 1.

most accurate way to get the tooth curves is to use a standard gear-cutter as a template, and to make the celluloid to fit this as in Fig. 5. The holes at *A* are drilled at the correct distances from the pitch line of the teeth to suit the various sizes of wheels to be drawn. In use, the template is pinned through the required hole to the center of the wheel on the drawing board, and is located for each tooth by the divisions previously made on the pitch line. It is advisable to locate the template for each side of the tooth separately; if both sides are drawn at one setting, the teeth will be too thick, since the pencil lines come slightly outside the template. Whether the teeth of a wheel are drawn by the aid of a template or with a compass, the pitch circle must be accurately divided. This is easy enough for multiples of 3 or 4, by the use of set-squares and bisecting the angles. When, however, we have odd numbers to deal with, the matter is not so simple. A protractor with a vernier will not be of much use when the required angle involves a few odd seconds of arc. A very useful circle

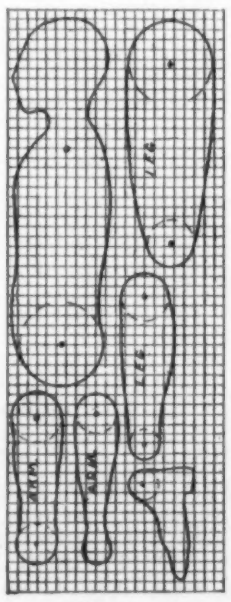


Fig. 4.

Fig. 5.

divider can be made from an odd pair of needle-point spring bows, or an equivalent tool can be filed up from a piece of thin sheet steel. The chief thing is to have the points exactly 0.7854 of an inch apart. The method of using this tool is shown in Fig. 6. First draw a circle, concentric with the one to be divided, with a radius of the same number of eights of an inch as the required number of divisions. That is to say, for 19 divisions make the radius 19 eights, or 2 3/8 inches, as in Fig. 6. The spring-bow dividers, or sheet-steel tool, if the points are accurately set to 0.7854 inch, will then be found to just go 19 times into the circumference of the circle. With ordinary care, and using a fine-pointed pencil in the compass, the dividing usually comes fairly exact. If not quite exact the first time it will be near enough to make the time a certainty. In case the circle for dividing should be inconveniently large, the radius may be taken in sixteenths of an inch, and the dividing tool made

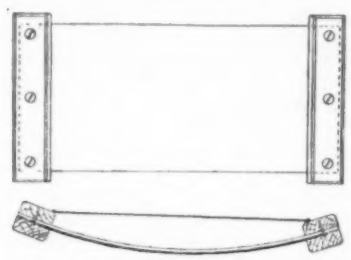


Fig. 7.

to measure 0.3927 of an inch. Once having made the divisions, it is a simple matter to project them on to the pitch circle which it is required to divide.

It sometimes happens that the orthodox method of obtaining one view of a part by projection from a view already drawn does not give the draughtsman a clear idea of its appearance, or time may not admit of a carefully projected view. Such parts as flat steel bars with a twist in one or more places, are, at times, difficult to visualize. In such cases a very useful accessory is a strip of sheet lead—say ¾ inch wide by 1/8 inch, or even 1/16 inch thick. This can be easily bent and twisted without tools, and gives at once a clear idea of the curves which should appear on the drawings of the various views. Another use for the strip of lead is for taking the outline of a molding, or similar part, which is not otherwise get-at-able.

Many draughtsmen, in addition to the usual mechanical drawings, have to prepare perspective drawings, and while there are some to whom this is easy, there are more who find it very difficult, and sometimes impossible. I have used the following method with entire success, and even an expert in perspective work will find it save a lot of time and trouble. An ordinary photograph is first taken of the machine, and from this a blue print, on good quality paper, is made. When dry, draw in on the blue print all the lines considered necessary, using waterproof drawing ink. Allow this a good 24 hours to get thoroughly dry, and then immerse the print in a weak solution of common washing soda. This will bleach out the blue and leave the ink lines only. Of course, this method can only be used for drawings of existing machines; but even so, it has its value for catalogue and advertising work.

While dealing with blue prints, a dodge for improvising a printing frame may be mentioned: When the usual

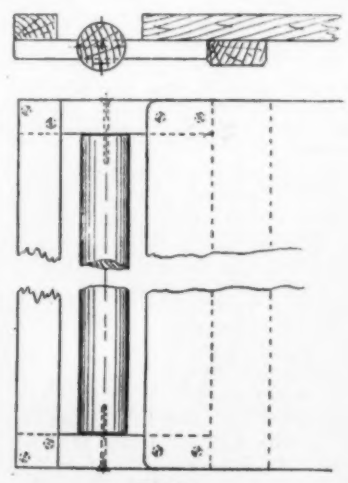


Fig. 8.

* *The English Mechanic.*

type of frame is not available, or one of the right size is not at hand, a piece of stout strawboard and four strips of wood can be made to do duty. Fig. 7 illustrates the idea. The tracing and printing paper are firmly clipped to the opposite ends of the strawboard by means of the wooden strips and a few screws. By slightly bending the whole thing, the tracing and paper being on the convex side, perfectly even and close contact between tracing and printing paper is secured. A couple of strings across the back will maintain the curve during printing. Progress of the printing may be observed by slackening the strings and gently reversing the curve of the strawboard. The tracing can then be raised sufficiently to see the print. Care must be taken not to shift the tracing or paper from the clamping bars. These improvised frames are particularly useful when prints are required from a larger number of tracings than there are ordinary frames for, in which case the progress of the printing can be observed in one of the ordinary frames, thus avoiding all risk of disturbing the tracings in the makeshift ones.

When a drawing, or tracing, has to be made which is longer than one's drawing board, a temporary straightedge for the T-square to work against can be attached to the board by a couple of battens, as in Fig. 8. This allows the paper or tracing cloth to overhang the end of the board without interfering with the T-square. By rigging up a light wooden roller between the battens, that part of the paper not being worked upon can be rolled up out of the way. The round stick from the center of a roll of tracing paper, or cloth, serves very well for such a purpose, and a couple of wire nails put through the battens make the pivots.

The three following hints are intended for draughtsmen in the early stages of their career: experienced men usually know them. Never use indiarubber for removing pencil lines and finger marks from tracing cloth, it generally smudges and seldom cleans the cloth. A piece of rag moistened with turpentine works like magic, and does not disturb ink lines. Also, if any difficulty be found in making the ink "take" on the cloth, do not use French chalk, as this clogs the pens. A wipe over with the turpentine rag does the trick effectually. When coloring either drawings or tracings, any tendency to "greasiness" of the surface preventing an even flow of the color is entirely overcome by a trace of soap mixed with the color. Just a couple of wipes of the brush on a cake of soap, and mixed into the color in the saucer will suffice. Many draughtsmen always use soap in this way, whether the paper be greasy or not. Certainly it is helpful in obtaining a perfectly even and flat wash of color.

It may not be generally known that a tracing or drawing in India ink can be transferred to drawing paper by placing it face down on the paper, and rubbing over the back with a smooth object, such as an ivory paperknife. This, of course, reverses the drawing; but when this is unimportant, a great saving of time is effected over the more usual method of re-drawing. Where it is needed to draw something to fit a part already drawn, this transfer dodge comes in handily. Moreover, it does not appear to detract from the original blackness of the inked lines, nor does the age of the ink seem to matter. Drawings made several years back transfer quite easily. The lines, though faint, are quite strong enough to be easily seen and inked in.

French Field Telephones

In a recent issue of *Die Umschau*, a German officer describes two field telephone sets that were found in a French fort captured by the Germans. The first set (Fig. 1) comprised a transmitter, a pair of receivers, and connections for a double wire circuit. The telephones are entirely magnetic and no battery is used. The employment of this primitive and antiquated apparatus impresses the German critics as "a classical example of French carelessness."

The second set of apparatus is of a very superior character. A condenser, a call bell, and an inductor for operating the distant call bell are mounted in a wooden box (Fig. 2). In transportation these parts are covered by a shelf, on which are stowed the head telephone and the hand instrument shown above the box, and the inductor crank shown at the right side. The box and its contents are carried in a leather case (Fig. 3), which has a separate compartment for the battery. The hand instrument carries a microphone, transmitter at one end, a receiver at the other, and a circuit closing key in the middle. The microphone consists of a thick and a thin plate of carbon separated by a layer of carbon grit.

The function of the condenser is to protect the telephones from direct currents, and its employment indicates the practice of telephoning and telegraphing over the same circuit—a practice long since abandoned in the German army. The German officer also criticizes the apparent use of a double wire circuit, as involving needless labor and delay in installation. The French

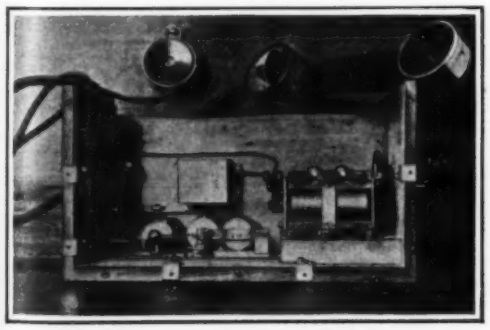


Fig. 2.—Improved French telephone apparatus.

apparatus will work over a single grounded wire, but in this case both bells ring simultaneously, which is very objectionable.

Heredity and Eugenics

Only a misguided enthusiast, says *The Journal of the American Medical Association*, would venture to make great claims at the present time for the possible future usefulness of applied eugenics. The doctrines of heredity on which the new postulates are based must first be subjected to critical investigation. The limitations of the practical aspects of eugenics must be clearly formulated and emphasized. It is well enough to maintain in a general way that vitality is partly inherited and partly acquired, and that "a sound physical and mental inheritance is a greater asset than the inheritance of extraneous advantages like wealth." Many individuals, however, have assumed that the new science is primarily intended to foster a scheme of general governmental interference with marriage. As a matter of fact, the most earnest students of the subject have at best hoped to promote the gradual establishment of standards in public opinion.

Submarines That Crossed the Ocean

The American public was recently interested in reports that five submarines, built in Canada for the British

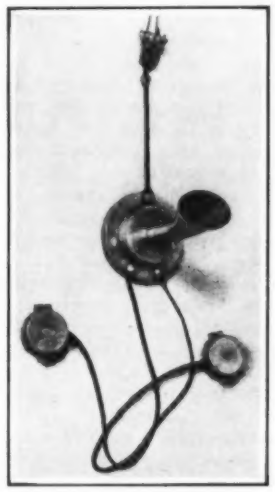


Fig. 1.—Primitive French field telephones captured by the Germans.

government, had successfully made the passage of the Atlantic, having taken their departure from Halifax, and are now doing good service "somewhere" on the other side.

From further information it appears that these vessels are the second instalment of ten boats that were built by the Canadian Vickers plant, near Montreal, from American designs, and are supposed to be the boats that were announced as having been contracted for by an American company, the building of which was prevented by objections from our Department of State.

These boats are each 160 feet long, and were built with the greatest secrecy, and how well the operations were concealed is demonstrated by the fact that practically nothing was published about the departure of the first lot of five, which made a successful passage from Canada to the Dardanelles early in the season; and it is supposed to be these boats that have done such excellent work both in the Dardanelles and in the Baltic, where an American-built boat is credited with having sunk the German battleship "Moltke."

While their speed at sea is supposed to have been quite slow, no casualty has been reported in connection with any of these boats, and the long voyage to the Dardanelles, about 7,000 miles, is by far the longest ever undertaken by any boats of this class, and far surpasses the performance of the German boats that are supposed to have proceeded from Kiel to the same destination.

The illustration on the first page shows the Canadian-built boats undergoing their final fitting out just before the start of their adventurous voyage, while the vessel on the dry dock belongs to the English navy.

Amorphous Boron and Magnesium Boride

The so-called amorphous boron, as prepared from boron trioxide and magnesium, has been investigated by Mr. R. C. Ray (*Chem. Soc. Trans.*, 1914, CV, 2162), who shows that it is never free from oxygen and magnesium oxide. The results obtained indicate that it probably consists of a lower oxide of boron, possibly in combination with magnesia, in a state of solid solution in amorphous elementary boron. The magnesia may be removed by fusing the preparation with boron trioxide. The crystalline variety of boron, which is approximately pure, does not enter into direct combination with magnesium, whereas amorphous boron yields a boride corresponding to the formula Mg_2B_2, which appears to be the only boride formed by heating the two elements to red-heat under the ordinary pressure. By heating this boride at a high temperature the magnesium is expelled, and a residue containing most of the boron in a crystalline state is left.—*Knowledge.*

As practically all the railway lines between France and Belgium are intersected by the trenches, it is not possbile, on many sections, to operate them by steam locomotives;

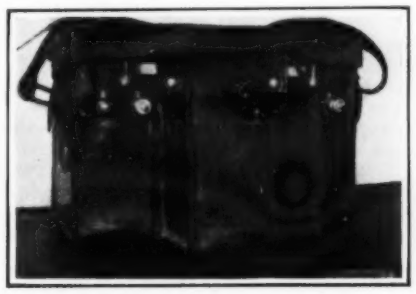
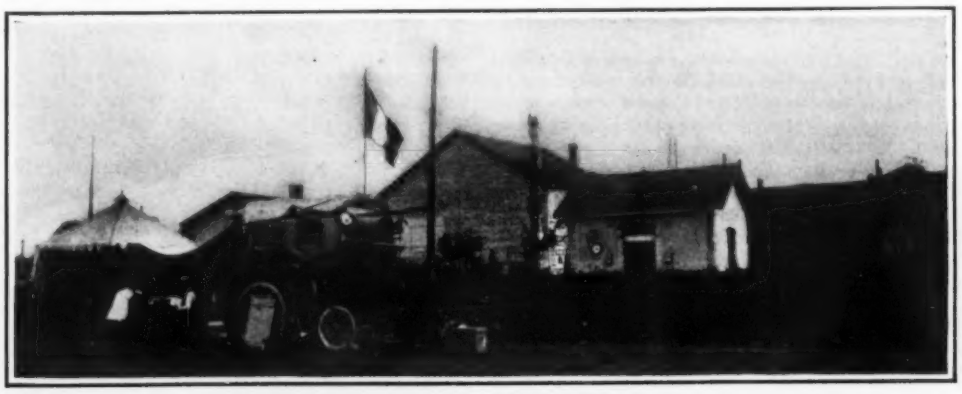


Fig. 3.—Improved outfit packed for service.

but the Germans are working these lines with cars operated by storage batteries, and they are thus being made very useful.



A French military portable telegraph and telephone station.

Applied Chemistry*

What the Chemist Has Done for Humanity, and His Relation to Manufacturers

By Dr. L. H. Baekeland

It is only three years ago that a Brooklyn alderman, who, in the absence of the Mayor of New York, had to welcome the visitors to the International Congress of Chemistry, addressed them as if they were druggists or pharmacists.

After all, he made not much greater a mistake than many so-called educated men who obtained a B.A. and yet are ignorant enough of elementary scientific knowledge to imagine that the main occupation of a chemist is to analyze substances and detect falsifications.

Even in England, a pharmacist is currently designated as "chemist," while a real chemist is called an "analytical chemist."

But the European war has done much to correct some of these mistaken notions of the public at large. Our daily press has now more or less acquainted this country with the fact that in our national make-up there is such a thing as chemical problems. I doubt, however, whether the unthinking masses have begun to realize that aside of the so-called chemical industry, practically every other industry, in fact, every enterprise, has chemical questions to contend with, and that chemical industry itself is intimately interwoven with the great network of every modern industrial or agricultural state; that the economic welfare of our country and the health of its citizens is largely dependent on the way we utilize our chemical knowledge.

The present war has been aptly called a "chemical war," because efficient work of every department of the fighting armies, from the Red Cross service to the manufacture of guns and explosives, involves incessantly chemical knowledge and still more chemical knowledge.

But do not imagine that this is the first chemical war. The art of killing and robbing each other became "chemical" the day gunpowder was invented; at that time, however, the existing knowledge of chemistry was just of pinhead size. Napoleon knew very well how to use adroitly exact knowledge and chemistry for furthering his insatiable ambition to dominate the world; so he surrounded himself with the most able chemical advisers and scientists, and for awhile at least he placed himself at a decided advantage over his many enemies; incidentally, he thus helped to lay the foundation for some very important branches of chemical industry.

"Les chiens ont appris quelquechose," exclaimed the Corsican conqueror when he realized that his enemies began to adopt the same means which had given him temporary mastership over them; but those whom he called so contemptuously "the dogs" finally beat him at his own game.

Ever since then, science, technology, and chemistry in particular, have played a rôle of increasing importance in the armament of nations. This accounts perhaps for the strange fact that the really great military inventions have practically all emanated from civilians and from non-military nations like our own. If the men of the military class, essentially conservative in all countries, had been left to their own devices, they would probably still be fighting with bows and arrows—or perhaps with the traditional sling. Nor should the pacifist blame the chemist if the latter's most beautiful conquests in science, if his proudest discoveries, have been turned into means of relentless destruction and human slaughter. Do not reproach chemistry with the fact that nitrocellulose, of which the first application was to heal wounds and to advance the art of photography, was stolen away from these ultra-pacific purposes for making smokeless powder and for loading torpedoes. Do not curse the chemist when phenol, which revolutionized surgery, turned from a blessing to humanity into a fearful explosive, after it had been discovered that nitration changes it into picric acid.

As well might you curse written speech or language or the art of printing—by which the most noble thoughts of the human race have been expressed, disseminated and preserved—if it has been used also to distribute the vilest lies and the most damnable errors.

Knowledge is like a knife. In the hands of a well-balanced adult it is an instrument for good of unestimable value; but in the hands of a child, an idiot, a criminal, a drunkard, or an insane man, it may cause havoc, misery, suffering and crime.

Science and religion have this in common, that their noble aims, their power for good, have often with wrong men deteriorated into a boomerang to the human race. Our very successes will threaten to devour us as long as all of us have not yet become imbued with the truth that greater knowledge, like greater possession of wealth or power, demands a greater feeling of responsibility, greater virtues, higher aims, better men.

Let us hope, in the meantime, that war carried to its modern logical gruesomeness, shorn of all its false glamor, deceptive picturesqueness, and rhetorical bombast, exposed in all the nakedness of its nasty horrors, may hurry along the day when we shall be compelled to accept means for avoiding its repetition.

Will you take it amiss if I make a digression from my subject as an answer to repeated attacks which have been made of late by some shortsighted men who blame our increasing scientific knowledge in general, and our chemical science in particular, for the excesses of the present European war?

But let us turn our attention to more peaceful chemical pursuits and more particularly to the chemists of this country.

Their work is difficult to understand and still more difficult to be appreciated by the uneducated or uninitiated; nor do chemists court the plaudits of an ignorant public that cannot understand them; they feel fully compensated by the results of their work if it only meets with the approval of a few of their fellow-chemists, irrespective whether it brings them financial results or not; in fact, most chemists are so much in love with their work that very often they neglect the financial side to their own immediate detriment.

Unlike the physician, lawyer, clergyman, actor, writer, artist, or business man, the chemist does not depend on the public at large; he is either engaged in some private enterprise or he acts in a consulting capacity for a few people, or he is teaching in some educational institution. Popularity in the usual sense has little or no value for the chemist.

No wonder then that the chemists of this country, numerous and active as they are, have hardly been noticed among the daily noise of newspaper sensation and shrieking publicity—no more than a skillful watchmaker would be noticed among the hammering of a busy steam boiler manufacturing plant.

And yet, right here in the United States, the chemical profession has taken such a root, such a development during the later years, that our national American Chemical Society, which counts over 7,000 members, has by far the largest membership of any chemical society in the world, with all due respect to England, France and Germany; a society which finds it possible to spend yearly over $100,000 on its three chemical publications, copies of which are to be found all over the world in every well equipped scientific library. Nor is the study of chemistry in this country a matter of recent occurrence. Our European friends are astonished when we tell them that as far back as 1792 there existed already the Chemical Society of Philadelphia, which was probably the first chemical society ever organized in the world; some of the papers presented at the meetings of that early scientific body furnish, even to-day, very interesting reading. Some of our American educational institutions equipped chemical laboratories for students at a time when exceedingly few of the best known universities possessed any such facilities. In fact, the Rensselaer Polytechnic Institute of Troy, New York, established a chemical laboratory at about the same time as was founded the famous laboratory of Liebig, at the University of Giessen, 1825, and the movement for the establishment of laboratories in the United States was independent of that in Europe.

Nor should we overlook the fact that, notwithstanding the essentially pragmatic tendencies of our country, the United States has given to the world a Willard Gibbs, who out-theorized existing chemical theories and whose mathematical deductions are still, after his death, furnishing food for profound thought to the most renowned physical chemists of Europe, to whom they have opened entirely new fields in the study of chemical dynamics.

I mention this more particularly for the reason that our aniline-dye consumers have taken the chemists of the United States bitterly to task, and have made decidedly unfavorable comments upon their abilities because, since the European war, dyes could no longer be imported from Europe. But Dr. B. C. Hesse, an American-born chemist, a graduate of the University of Michigan, has already ably answered this indictment of the American chemists. In a paper full of information on this subject, which he presented at the New Orleans meeting of the American Chemical Society (see *Journal of Industrial and Engineering Chemistry*, Vol. 7, No. 4, April, 1915, page 293), but which, unfortunately, has received little or no attention from our daily press, he has clearly demonstrated that the aniline-dye consumers of the United States can have all the chemists and all the dyes they want, provided they are willing to make the necessary investments of capital, and to submit to the risk of uncertain profits by starting their own dye-manufacturing establishments here in the United States instead of, as in the past, favoring imported dyes, either through personal prejudice, or by fostering legislation which forbids the home manufacturers to utilize such methods of selling agreements as "Kartels" or other consolidations of interests; or "dumping," so as to kill new competitors in the field, while making up the temporary loss by increasing the price of other products, and in general, any of the many other trade arrangements and trading tricks freely and openly utilized by European manufacturers so as to stifle possible competition of our home aniline-dye producers.

The outcry which has been raised as to our shortage of artificial dyes is out of all proportion if we take into consideration that the annual importation of dyes and synthetic products from Germany amounts only to about $9,000,000. Mr. A. D. Little, a former president of the American Chemical Society, pointed out (see *Journal of Industrial and Engineering Chemistry*, Vol. 7, No. 3, March, 1915, page 237) that this represents about the same money value as the amount of candy sold annually by the Woolworth Ten-Cent Stores.

The development of any chemical industry is a matter of local opportunities; for instance, the manufacture of cellulose, as well as the industry of wood-distilling, have taken a greater development in the wood-covered sections of the United States than in Germany or any other country in the world.

The magnitude and earning capacity of the largest German chemical enterprises, however imposing they may be, look less important if you take into consideration that some of these companies have been in existence for more than half a century. Much younger American chemical enterprises, which make American specialties—for instance, the Eastman Kodak Company, which sends its films and photographic papers throughout the whole world—have annual earnings decidedly greater than the most successful German chemical works of much older existence. Nor is the value of the output of some of our largest purely chemical companies much less important than that of the German concerns.

This country is now the greatest producer of sulphuric acid, with an annual production of about 3,000,000 tons. Yet it is not so long ago that the first maker of sulphuric acid had trouble to find purchasers for a triflingly small production of a few tons per week. It needed the opportunity of a home market; by and by this market was created through the refining processes of petroleum after the discovery of our oil fields; the discovery of natural phosphates and the resultant industry of superphosphates; the use of dynamite for blasting, the development of the glucose industry, electrolytic copper refining, etc. These and many newer industries all required large amounts of sulphuric acid, and gave this country an opportunity of developing sulphuric acid manufacturing to its present magnitude. In fact, the same reasoning holds good for all of our industries. I doubt very much whether the talented foreigners, who have now become famous in chemical manufacturing, would have tied their initiative and enterprise by specializing in coal-tar dyes manufacturing if they had had the limitless opportunities of an immense undeveloped country like ours, which give other outlets to their spirit of pioneership; mining, transportation, agriculture, and similar subjects, all beckoning for more urgent attention, and offering at the same time more immediate rewards.

In the meantime some of our other chemical industries, better suited to our local conditions, have taken such an enormous development here as to make the United States an undisputed leader in at least some of them. Such products as the various acids and salts, aluminum, artificial abrasives, calcium-carbide, soda and caustic alkalies, bleaching powder, chlorine products, electrolytic copper, are decidedly more imposing in value and in economic importance than the few million imported coal-tar dyes.

F. A. Lindbury of Niagara Falls (see *Metallurgical and Chemical Engineering*, Vol. XIII, No. 5, 1915, page 277) pointed out rightly that if there had been a shortage in some of the products of our electrochemical industries, in which the United States has been a pioneer, the consequences to our national economics would have been so serious that the present complaint of our aniline-

* An address presented at the meeting of the American Chemical Society, Seattle, Wash.

dye users would have sounded like a timid whisper compared to the bellowing lamentations of so many more important industries which would have become absolutely paralyzed. The fact is that few men realize how many industries are directly dependent on the work of American chemists. If the aniline-dye industry has been neglected in this country there are many other good reasons for it; not only was the possibility of reasonable profits too scant to offer special inducement to clever-headed business men for risking their capital in this branch of manufacturing, when they had so much better choice in other channels of enterprise, but the first raw material, suitable coal tar, was not abundantly available here, as it is in Europe, for the simple reason that this country long ago discarded the older and more expensive methods of gas manufacturing still generally used in Europe, and which give coal tar as a by-product. The less expensive and simpler water-gas process, adopted in the United States, gives no suitable gas tar; it is only of late, by the introduction of the by-product coke ovens, that we can look forward to an almost unlimited supply of coal tar.

In the meantime the German manufacturers, while possessing every opportunity and inducement for specializing in these coal-tar industries, could afford to concentrate their efforts so as to supply not only their home consumption and that of the United States, but that of the whole world; in about the same way as the United States sends to the remotest corners of the globe its sewing machines, its typewriters, and its Ford cars.

Judging from the past history of the chemical industry in America I have little doubt that the day it will be found profitable to manufacture all kinds of synthetic dyes here in the United States, instead of a few as is the case now, there will be little further delay in supplying the demand by a hustling and bustling home production.

In fact, it is quite possible that, under the present conditions, this branch of manufacturing may be stimulated to such a point as to result in over-production after the war is over.

If hitherto our chemists have been deficient in this special line we can, with some satisfaction, point to better efforts in other chemical industries. For instance, it is not sufficiently known how many research chemists in our different American manufacturing establishments are busily occupied in studying and improving manufacturing processes, nor what large sums of money are devoted every year to industrial chemical research. If we hear it constantly repeated that some of the largest German chemical companies employ hundreds of chemists and engineers, it is less known that right here in the United States the number of chemists employed in some of our better organized chemical enterprises is scarcely less; but nobody finds it necessary to boast about it. In fact, the most striking symptom is that so many engineering enterprises, for instance, some of our large electrical companies—although their field of action seems rather remote of chemical subjects—have now elaborate chemical research organizations with an excellent record.

Conditions were quite different some fifteen or twenty years ago; but this country has grown, and as the requirements and opportunities grew up at the same time, new chemical problems arose thereby.

The urgent nature, as well as the magnitude of some of these new chemical problems, is shaking our chemists awake—is making new men of them.

Professor Whitaker is probably right when he says that, from the standpoint of efficiency, the chemists are thirty years behind the engineers as far as method and attitude of mind is concerned; but this same criticism holds good for chemists all over the world. The fact is, that the engineer was called first, and he was born centuries before the chemist; but the latter is now making up for lost time.

New conditions, new problems, are compelling the chemist to learn to tackle a proposition in a true engineering spirit and—to hitch some business sense to it. He is learning to forget thinking or acting on the test-tube plan; he is thrown more and more in contact with business men; he begins to realize that too one-sided theoretical considerations are sometimes more dangerous than complete ignorance; and that a sense of proportion and relative values is the first requirement for good practical effort.

Here, indeed, is one of the weakest spots of the chemist. Aside from the fact that the chemical profession seems one of those vocations which have fascinated a large number of intellectual freaks, it has generally attracted men of an analytical rather than a constructive turn of mind. Successful engineering is essentially constructive. The most urgent work for the chemist of to-day must be constructive—he must learn how to cement together the vast amount of data which already lie at his disposal, even if he, himself, has to provide some of this very cement by further research.

The chemist of to-day is no longer confined to purely chemical enterprises; even the most stubbornly conservative manufacturers have learned, through competition, that every industry, however mechanical be its nature, has its chemical problems. Things have changed rapidly since the day Andrew Carnegie listened with a sly twinkle in his eye to the fun his competitors were poking at him when he first engaged a spectacled professor to investigate the chemical problems in his iron works. Conditions have now become reversed; to-day a steel or iron works without a competent chemist justly provokes contempt and distrust.

Nor is the time so far distant when even our biggest railroads had not begun to realize how they missed the constant services of a staff of chemists, so as to advise them in the various chemical problems which present themselves in the operation of a well organized railroad system.

Some time ago I visited the plant of the National Cash Register Company in Dayton, Ohio. One of its most interesting departments was its well-equipped chemical laboratory, where no end of chemical questions relating to the manufacture of purely mechanical devices have to be studied and solved. No up-to-date motor-car works is complete without its chemical department, and the same remark holds good for all well-organized engineering companies.

In the United States the importance of chemistry has been appreciated first in its relations to agriculture. So obvious was this that we set an example to all other nations of the world by the number and extent of our federal and our state chemical agricultural laboratories. This, more than anything else, was the entering wedge of applied chemistry in this country, which extended, later on, to the Government Service, the Geological Survey, the Bureau of Standards, and the Bureau of Mines. Nor did the useful effect stop there. Many of our federal chemists, our state chemists, have left public service, to accept better paying positions in private industries; but these men, trained in public service, implanted their high aims and scientific ways in some of our commercial enterprises, which needed them badly. I know of some cases where this beneficial influence changed radically the whole tone of the commercial organization, from its manufacturing to its selling department, and introduced, instead of reckless, sordid commercialism, a spirit of fairness and efficiency which soon proved the more profitable policy.

In this and similar directions, the chemist can exercise a valuable moral influence on the community. If you think it over you will find that the quest for efficiency lies quite close to the path of honesty, justice, and equity.

Here also the chemist has much to learn. In some instances I have been astounded at the almost childlike attitude of mind of some of our chemists, who are too ready to sell their services to anybody who has a temporary use for them, irrespective of the underlying motives or purposes.

Some lawyers tell me that they never have the slightest difficulty in hiring chemical experts to defend contradictory opinions. For instance, it is quite amazing how some chemists, in their eagerness of pleasing their employers, will overlook their own ignorance of the most elementary principles of patent law, as well as their superficial acquaintance with the many details of intricate technical questions, while not hesitating to furnish cock-sure opinions which encourage infringers or industrial pirates to trespass on the rights of intellectual property of others. Much ruinous patent litigation would be avoided in this country, and invention would be better encouraged, if we had more men of the type of that well known British electrical expert who never hesitates in court to tell the simple and direct truth, regardless whether it kills or saves the case of his client. His statements are so highly valued and respected that the judges accept them without suspicion, and the same expert is frequently retained by the two opposing parties, whom he serves impartially, and who gladly pay him higher fees than to a mere litigation-acrobat expert, or a chemical "ambulance chaser."

The ethics of our profession have been dealt with by the American Institute of Chemical Engineers, and have been embodied in its recently adopted Code of Ethics, which may furnish a good guide for younger or less experienced chemists. And this leads me to state that many more manufacturers or business men would be induced to utilize the services of chemists if they could feel confident that, in so doing, they are not putting themselves at the immediate mercy of a stranger, by confiding to him unreservedly facts or processes which it has cost them many sacrifices of time and money to accumulate, and the undivided knowledge of which constitutes, sometimes, one of their most valuable assets. On the other hand, a chemist can hardly be of any service unless his client or employer is just as frank with him as he would be with his lawyer or physician. However, this mooted point is easily overcome by referring to the Code of Ethics to which I have just alluded, or better, by making a preliminary agreement between the chemist and his client or employer, safeguarding the interests of both parties. But in such a case the compensation to the chemist should be made commensurate to the occasion.

This same principle holds good in the employment of chemists in manufacturing plants, where the chemist is either engaged in research or in a manufacturing capacity. An employer should not expect an intelligent chemist to render him important services without proper compensation; and in as far as the practical value of the work of a chemist can seldom be determined in advance, it will pay the employer to offer special inducements or rewards for initiative. He can well afford to give his chemist some share of the increased profits he has received through his work; to do otherwise would be narrow-minded, short-sighted, and detrimental to the direct interests of the employer. The work of a research chemist cannot be performed nor measured like that of a bookkeeper or a laborer, the best results of his work are uncertain; delays and obstacles beset him at every turn; sometimes luck plays an important rôle; but good will, enthusiasm and persistent endeavor are indispensable factors, and these may be encouraged or killed by the attitude of the employer. An employer who is unfair, or who cannot arouse the respect or the enthusiasm of his chemists, cannot get the best there is in them; he must make them feel that if their work turns out well for him they will get some fair share of compensation. Therefore a reasonable salary ought to be supplemented by the possibility of a bonus, or some share in the profits, based on earnings brought about directly by the work of the chemist.

On the other hand, the chemist must not overlook the financial sacrifices and business risks assumed by his employer. He should specially bear in mind that knowledge or experience gathered at great cost by his employer, or through expensive factory equipment or other special facilities, have, in most cases, enabled him to take up his own part of the work at an advanced stage. It would be rather unfair, unless otherwise stated, that a chemist should be allowed, during or after his period of employment, to divulge or take advantage of all the confidential knowledge or information gathered around the works in which he is employed; or patent for his exclusive benefit any invention he may make on those particular subjects for which he is engaged, as long as the stimulating ideas themselves have been gathered by the very means put at his disposal by his employer. All these questions should be provided for and embodied in an equitable contract, which will necessarily vary with special circumstances. But here again, niggardliness, or too great cunningness of the employer, will hardly pay. Unless his chemist be a fool—and a fool of a chemist is not worth anything—his employer will lose the good will and confidence of the very man whose work is dependent on these indispensable factors.

Faithful and generous observance of these conditions has brought about the most excellent results in many instances. I know that the contract system, with a salary supplemented by a bonus, or some participation in profits in special departments, have been used with great advantage to all concerned by some of the most successful chemical companies in continental Europe, and in some of the more progressive American enterprises.

It has been objected that a contract of the kind merely binds the employer who has tangible assets, while in most cases it would be difficult to enforce it against faithless employees possessing no property. But even then, a clear and well defined contract will prevent many misunderstandings which may crop up in the course of time. It has been my experience that direct dishonesty and faithlessness are merely exceptions among chemists, whatever their other shortcomings may be.

We know where the work of the chemist begins. We can never tell where it ends, and through what unexpected ramifications it may lead. It is just this fact which adds some zest to the life of the struggling, hard-working chemist, and brings to his work frequently as much excitement as the best of sports; his hopes and disappointments can be compared to those of the restless prospector.

Pasteur, while he was professor at the University of Lille, was consulted by a local alcohol distiller about some irregularities in the fermentation processes. Little did the great French chemist dream, when he tried to solve this seemingly trifling industrial problem, that by doing so he was going to lay bare such an amount of new and unsuspected scientific facts, destined to upset all formerly accepted notions, not merely on fermentation, but on life, disease, contagion and epidemics; that he was about to revolutionize surgery, sanitation and medicine, and create several new departments of medical science; that he was going to save millions of lives—reduce sorrow and misery. So little were the men of that period prepared for all these stupendous revelations, that this great benefactor of the human race had to suffer most from the gibes and violent attacks of some of the best known men of that very medical profession into which he was going to infuse new life by placing it on a true scientific basis.

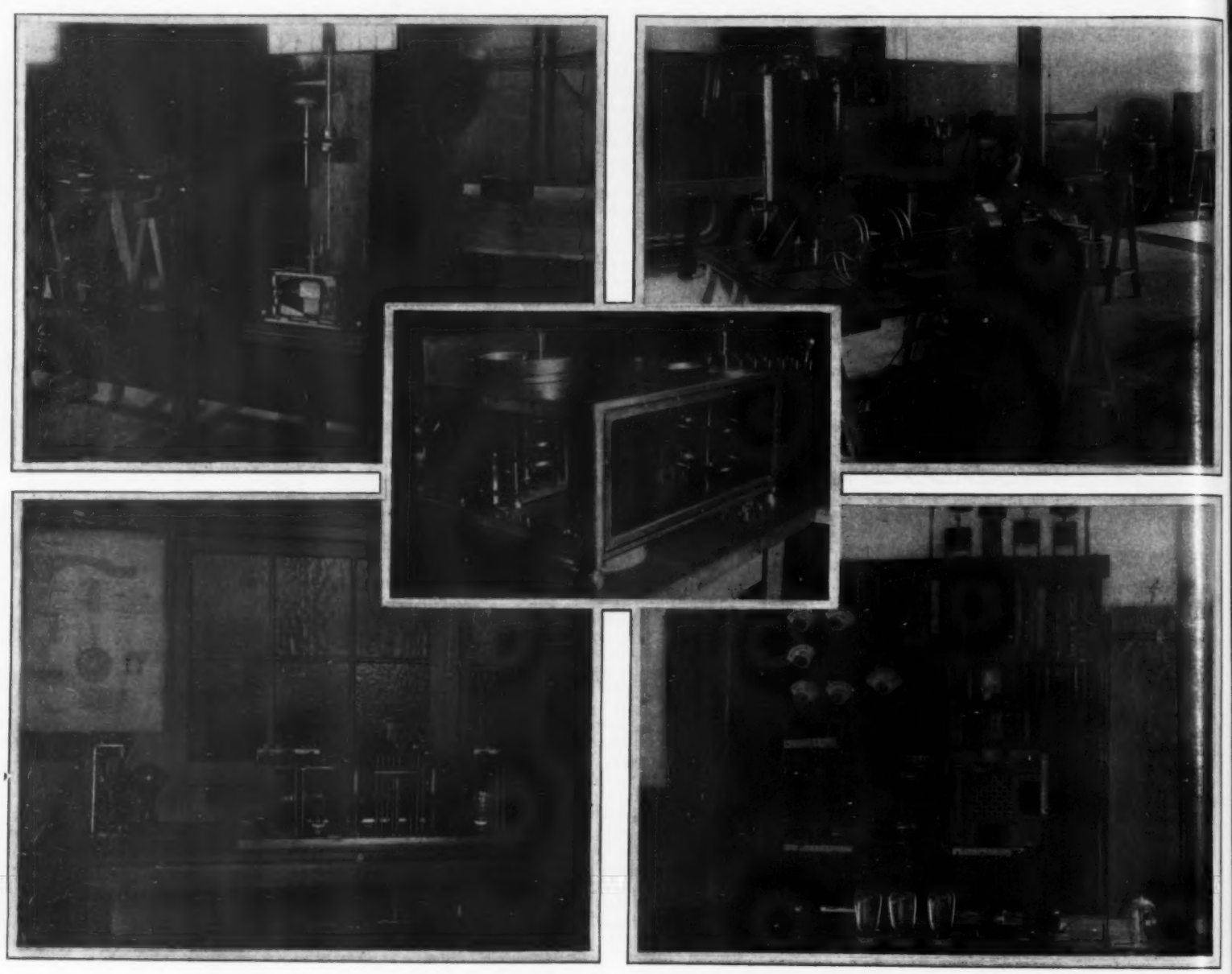


Fig. 1.—Some devices designed by Torres.

Upper Left.—Universal accellerator. Upper Right.—Testing lubricating oils. Center.—Universal pantagraph. Lower Left.—Wireless boat control. Lower Right.—Automatic chess player.

Torres and His Remarkable Automatic Devices

He Would Substitute Machinery for the Human Mind

THE Spanish inventor L. Torres y Quevedo is already known for a number of remarkable inventions, one of these being a most ingenious apparatus for solving algebraic equations, while more recently he designed an airship which now forms part of the French military equipment under the name of the "Astra-Torres." We wish to refer to the work of this inventor which he is engaged in carrying out at his large and well-equipped mechanical laboratory at Madrid, subsidized very liberally by the government: his idea being to develop the question of automatic mechanism in order to allow mechanical devices to make a wide number of most complex movements, such apparatus having a most practical bearing in the industries.

The Paris University invited M. Torres to make an exhibition of several of his most interesting devices, and accordingly they were mounted in working order in a section of the new laboratory of Mechanical Physics. One of these devices which attracted much attention is a mechanical chess player, it being, however, constructed with another end in view, this being to demonstrate certain of the inventor's ideas relating to automatic mechanism of a very complex character such as he claims can be carried out. In the present apparatus, the chess board, which makes up a comparatively small part of the whole, will be seen toward the right in Fig. 1, it being mounted in an upright position. The game is indeed not a complete one, and is here reduced to a single element, that is, the machine plays with one white king and one rook against one black king which the spectator can move as he desires. Even thus simplified the possible number of combinations that the machine has to provide for is very great, hence, the elaborate apparatus, and besides the machine is required to actually move the pieces, these being in the shape of jack plugs. The square frame surrounding the board provides for a double slide piece which can come over any one of the squares and then pick up the plug by clamping its head, withdrawing it, and then sliding again into a new position, inserting the plug into another square and then traveling off to the repose position clear of the board, leaving the surface of the latter free.

When we make a move by inserting the black "king" on any square, the machine first examines whether the move conforms to the rules. If not, it "protests" by lighting up one of the electric lamps seen on the base; but should the move be correct the machine takes account of the position of the three pieces, decides the move to be made and displaces one of the pieces as we have above seen. The game thus continues until the machine finally checkmates the opponent's king. No more than three false movements can be made by the opponent, each time a lamp being lighted, but after the third lamp, the machine refuses to work, and a special switch needs to be closed in order to commence a new game, the lamps then going out and the machine puts the pieces in the zero position. M. Torres explains his general ideas on the construction of electric automatic machines as follows:

The ancient automatons, among which the most celebrated is Vaucanson's "duck" and others of his devising, imitate the appearance and movements of living beings, but this has not much practical interest, and what is wanted is a class of apparatus which leaves out the mere visible gestures of man and attempts to accomplish the results which a living person obtains, thus replacing a man by a machine. In a submarine, which must keep a certain definite level in the water, the man in charge watches an aneroid and a level-indicator which show him the boat's depth and inclination, then he operates the rudder accordingly, so as to keep at the same depth. A torpedo, on the other hand, uses analogous instruments in order to automatically control the steering, human work not being used. Here, however, the nature of the movements is not a complicated one, and the result is easily obtained. But when it comes to an apparatus in which the number of combinations makes a very complex system, analogous in a small degree to what goes on in the human brain, it is not generally admitted that a practical device is possible. On the contrary, M. Torres claims that he can make an automatic machine which will "decide" from among a great number of possible movements to be made, and he conceives such devices, which if properly carried out, would produce some astonishing results. Interesting even in theory, the subject becomes of great practical utility, especially in the present progress of the industries, it being characterized, in fact, by the continual substitution of machine for man; and he wishes to prove that there is scarcely any limit to which automatic apparatus may not be applied, and that at least in theory, most or all of the operations of a large establishment could be done by machine, even those which are supposed to need the intervention of a considerable intellectual capacity. When the principle which he uses in the present chess player is examined, he is certain that any one will be convinced of the truth of his ideas, and he is now working

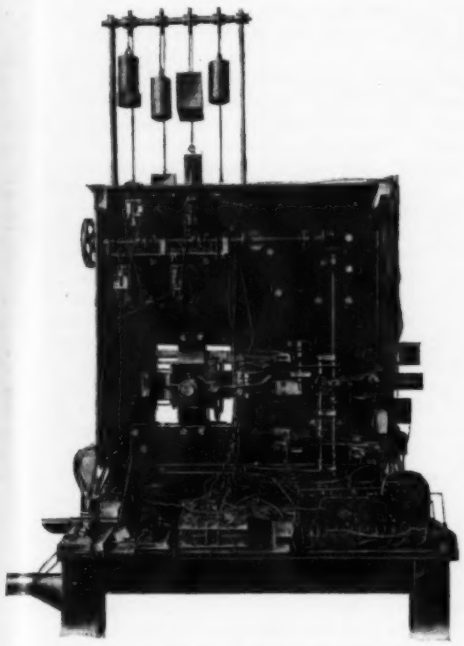


Fig. 2.—Back of automatic chess player showing, gearing and mechanical action.

to develop them on a wider scale.

Among the apparatus shown at Paris is a device which is intended to show that a mechanical movement of a given character can be transmitted to a given device not only when the latter is making a regular movement, but when it moves in a very irregular way. In this case it would be thought impossible to produce the same result, but the idea is very well demonstrated in an apparatus which contains a fixed cardboard disk placed in the right hand circle on the top of the cover (shown in the central illustration in Fig. 1) and a second disk mounted in a metal frame on the left. But this frame is movable and can take various irregular positions. The operator first selects a certain figure, such as a letter of the alphabet, *A*, and works the extensible handle so as to inscribe this letter by means of a pencil upon the fixed disk. With the second disk at rest, a pantagraph movement inscribes the same letter, *A*, on the second disk, this, of course, being very easy. What is remarkable is that in a second case, the operator proceeds to inscribe the letter upon his disk, while another person takes hold of the left hand disk and moves it about in any irregular manner. But this does not prevent the machine from inscribing the given letter upon the second disk as before, for all the irregular motions are exactly compensated for in such way that the machine acts as if the second disk were quite steady, and the result is practically the same as in the first case. It will be seen that if the second disk represents an irregularly moving mechanism, or an object which is being transported by crane or other device and swinging in space, such movements will not present any desired result from being obtained by the action of a controlling mechanism, in spite of the various motions of the object.

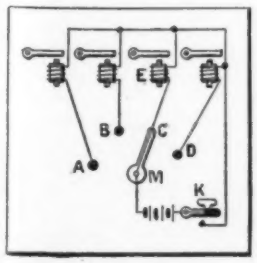


Fig. 4.—Switch giving four selections.

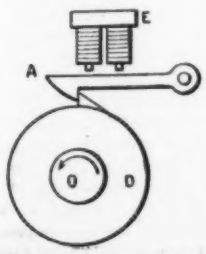


Fig. 5.—Escapement wheel with detent.

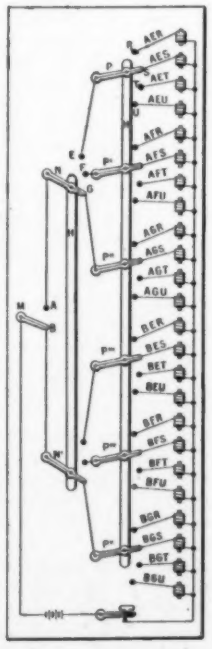


Fig. 6.—Switches controlling 24 operations.

One of our views in Fig. 4 shows a method for wireless steering of boats which was very successfully applied upon a good-sized boat containing a number of persons. On this occasion the boat was run in the harbor of Bilbao, and could be steered in all directions, started, stopped and run at various speeds.

By examining the picture (Fig. 1, lower right hand), which presents the face of the chess player, the board will be seen as a very small portion of the machine, being mounted in the vertical toward the right. The game is not a complete one, being here reduced to a simple element, the machine playing one white king and one rook against one black king which the spectator may move as he desires. Even simplified to this degree the possible combinations will be very great, in addition to which there is the mechanism required to actually move the pieces, which are pins or plugs fitting into holes in the squares. At the top and left of the board will be noted two arms which can combine to cover any square, seize the piece therein by its neck, lift it clear, transfer it to any other desired space and place it in its position there. The arms then retire to their neutral positions.

When the spectator moves his king, the machine first tests out whether it is according to rule, and if not, it protests by lighting one of the lamps at the base. If the move be a correct one, the machine takes account of the position of the three pieces, decides the move to be made by it, and makes the move. The game thus continues till the machine finally checkmates the king of the man. No more than three false moves are permitted, a lamp being lighted each time, and following the third one the machine refuses to continue and a new game must be begun. This is effected by closing a special switch, whereupon the machine extinguishes its lamps and sets the pieces in the zero position again.

The novelty in the matter is that the machine looks over the field and selects one possible action in preference to another. There is, of course, no claim that it will think or accomplish things where thought is necessary, but its inventor claims that the limits within which thought is really necessary need to be better defined, and that the automaton can do many things that are popularly classed with thought. It will do certain things which depend upon certain conditions, and these according to arbitrary rules selected in advance.

While it is out of the question in the space available to describe the chess player in detail, it is still possible to set forth some of the principles which it utilizes. One of these is that the pieces are plugs and in each of their

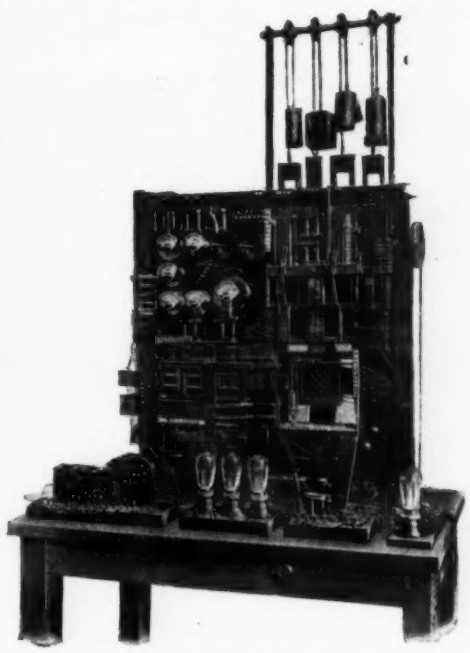


Fig. 3.—Face of automatic chess player.

individual positions on the board they make connections through related relays. Then there is the commutator principle that is everywhere in use. Fig. 4 illustrates this, *M* being the commutator governing any of the contacts *A*, *B*, *C*, or *D* at will. Under the conditions here shown it is the electromagnet *E* that is in circuit and whatever further movement is made it is one that must initially be related to *E*. Fig. 6 presents a more complicated arrangement, the commutators being in three groups, *M*, *N*, and *P*. Commutator *M* may take either one of two positions with corresponding circuits, *N* and *N'*, have the choice of three each, and the group *P* to *Pv* have four contacts each. Such a combination permits of twenty-four different operations. Theoretically, it will be necessary merely to multiply such an arrangement to accomplish almost anything desired in the way of direction of future action, but practice interposes its

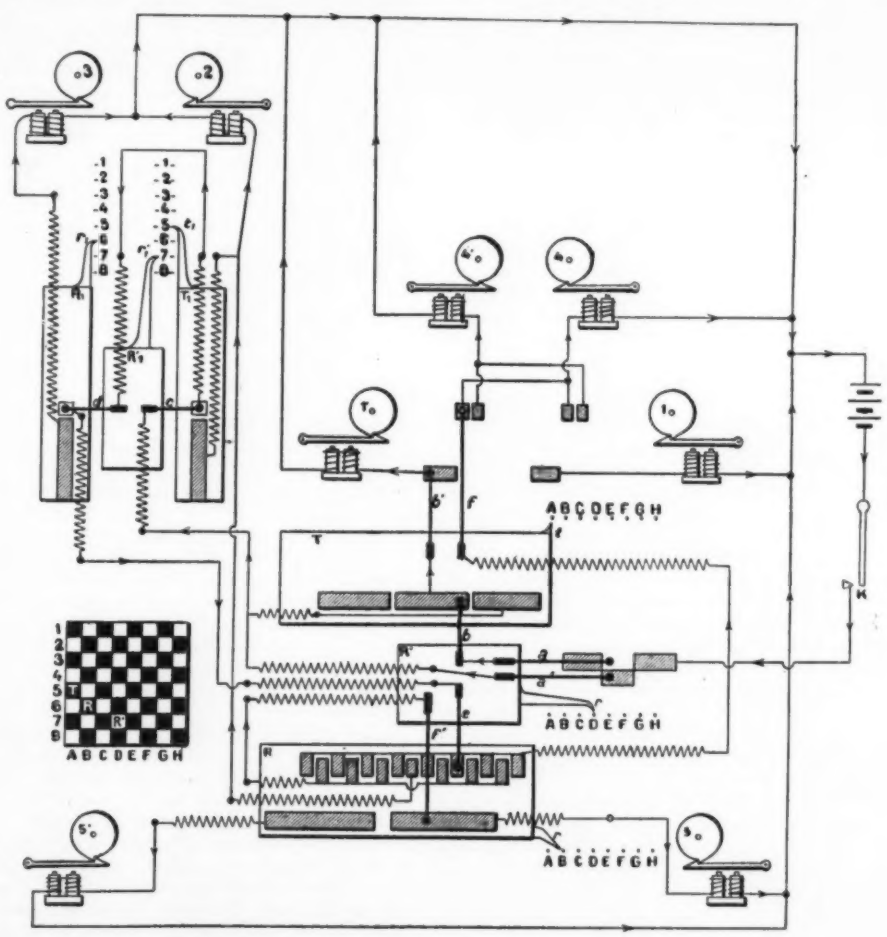


Fig. 7.—Scheme of electrical connections of automatic chess player.

The board is plainly shown, with its vertical columns, and the horizontal rows numbered. *R* and *R'* are the white and black kings, respectively, and *T* is the white castle. Rectangles *R*, *R'* and *T* are movable tablets, whose contact points mark the columns of the corresponding piece; rectangles *R*-1, R'-1 and *T*-1, similar tablets marking the horizontal rows of the corresponding pieces 1, 1', 2, 3, 4, 4', 5 and 5' are wheels held by pawls which are armatures of electro-magnets. Currents in the latter release the corresponding wheel, or wheels for one revolution. Each wheel initiates some definite action.

limitations. Action is secured, as shown in Fig. 5, by escape wheels the detents of which are the armatures of electro-magnets.

When the visitor has moved his piece, the automaton first tests whether it is a correct move, if not, a lamp is lighted. Assuming the move to be according to the rules, the machine determines upon one of six operations and the way of getting at which one is this—it being, of course, understood that the machine is already set in certain ways by the positions of the pieces:

Assuming that the black king					
is in the same zone* with the castle.†	is not in the same zone with the castle and the vertical distance between the black king and the castle is				
	more than one square	equal to one square, the vertical distance between the two kings being			
		greater than two squares	equal to two squares and the number of squares that measures the horizontal distance is		
			odd	even	not any
		The result will be			
castle moves horizontally.	castle descends one move.	king descends one square.	castle moves one square horizontally.	White king moves one square toward black king.	castle descends one square.
1	2	3	4	5	6

* "Zone" is used by Torres to indicate one of the three groups of vertical columns, *A, B, C*; *F, G, H*; or *D, E*.

† To avoid possible confusion the term "castle" is used here instead of "rook." The diagrams being from the French, *R* represents the king (roi) and *T* the castle (tour).

The study of the application of these decisions is suggested in Fig. 7. The various rectangles are tablets movable in the direction of their greater length which carry points making circuits through contacts 1–8 or *A–H* which correspond with the horizontal rows of squares or vertical columns as may be seen by referring to the board itself. The three lower central tablets are for the rows or horizontal ranges of squares, *R*, *R'* and *T*, being related respectively to the white king, black king and castle, while the upper tablets, above the board, R_1, R'_1 and T_1 indicate the vertical positions of the same pieces. These tablets change in position with the moving of the pieces. Circuits are established through the points of these tablets which actuate one or another of the single-leg escape wheels, permitting them to do their especial functions by attracting the pawls and giving them one revolution. What they do may be arranged, for example, in some such way as this:

1 carries castle to column *A*,
1′ carries the castle to column *H*,
2 carries the castle downward one square,
3 carries the king downward one square,
4 carries the king one square to the right,
4′ carries the king one square to the left,
5 carries the castle one square to the right,
5′ carries the castle one square to the left.

On the initiative of these wheel movements other mechanism accomplishes the desired results, and in the process of moving the tablets change to accord with the new position, affording means of checking up the propriety of the move and furnishing the basis for the new scrutiny that will determine the next move.

The foregoing description is necessarily sketchy and imperfect, but it will serve to give an idea of the kind of machine that is occupying the attention of Torres. The problem to begin with is a definite one in which there is the mathematical certainty that the white pieces can mate the black king. For chess it is a relatively simple matter but at the same time it affords great range in the way of doing it. Torres has become acquainted with the mathematics, has arrived at rules which will lead to the desired results and has been ingenious enough to invent devices which will follow these rules. Fig. 1 gives some idea of the complexity of the electrical layout, while Fig. 2, the back of the machine, shows some of the mechanism whereby the mechanical movements are effected.

In the automatons of Torres there is the extraordinary interest that while without meretricious imitation of the human form they attempt the accomplishment of things that have hitherto been reserved entirely for the human mind. In a submarine the man who directs it keeps his eye on clinometers, manometers, aneroids and compasses which indicate heel, inclination, submergence and course of the vessel, and maintains his proposed direction by the indications that these furnish him. In the automatic torpedo analogous instruments themselves direct the course without human intervention. Such methods of control bear the suggestion of the further use of machines in the industries. It would seem as if factories had already reduced their processes to automatic ones to the last degree, and are utilizing labor for care rather than for direction. Torres believes that the limit has by no means been reached of what automatic machinery will do, and in substantiation of his opinions presents his automatic chess-playing machine.

The Steel Industry and a Year of War*

A Review of Conditions in Four Leading Countries

A REVIEW of the steel industry in the first year of the war is given by Dr. E. Schrödter of Düsseldorf in the last issue of *Stahl und Eisen* to reach this country—that of August 5th. Considerable extracts are given below:

THE GERM N STEEL INDUSTRY.

Hard work under difficult circumstances characterizes the activity of the German iron industry in the first year of the war. In the last year of peace, 1913, Germany mined about 35,941,000 metric tons of domestic iron ore and produced out of this, outside of a sale for export of 2,613,000 tons and an importation of 14,019,000 tons of ore, a total of 19,300,000 tons of pig iron; that is, about 40 per cent of the metal content of our pig iron came from foreign sources. The necessary fuel, with a few minor exceptions, was domestic. But we were dependent on foreign sources, not only as regards our imports of iron ore, but in much greater measure was this the case as to the sale of our products in finished and semi-finished steel, for in the same year, 1913, our exports of iron and steel, including machinery, figured back to pig iron, were not less than 46.6 per cent of the year's production. That an industry which, in so great measure, depended on its foreign relations, both as to imports and sales, should be thrown into the most intense suffering by the unexpected outbreak of war is easily understood.

At the regular meeting of the Association of German Steel Makers on January 31st, 1915, I gave a detailed account of this, and I was also able there to call attention to the gratifying resuscitation which had set in a few weeks after the first stagnation and to the effective transformation which had already made itself manifest. Since then the rate of production has not only been maintained, but it has increased in a satisfying degree. A large number of blast furnaces are again in blast and others are constantly being lighted. Though the average production of each furnace has decreased as a result of poorer ores, yet the daily output of 18,925 tons in August, 1914, has grown to 31,400 tons as the average of the last few months.

The steel production has developed in a similar manner. From the low figure of 18,310 tons per day in August, 1914, it has advanced to an average daily output of 33,000 tons in 1915. It is self-evident that the activity of the rolling and other mills was correspondingly greater.

LACK OF MANGANESE.

A special writer in the London *Times* last spring figured that the German steel industry would have to stop by June, 1915, because of a lack of manganese. The hail of the steel of our guns has demonstrated that this estimate also belongs to the enemy's many false computations of this war. The production of our iron industry, dependent on domestic raw materials as it now is, is so great that it fulfills not only all the demands of our army and fleet, but also the necessary current needs of steel for domestic purposes and even to a certain extent the wants of our neighboring neutral nations. This gratifying achievement is public knowledge. How we protect ourselves in our raw materials is our own metallurgical secret which we have no occasion to reveal to our united enemies. So much, however, may they know—the idea of a dearth of steel for our war needs because of a collapse of our steel industry is a miscalculation, the same as the plan to starve out our population during the war has proved itself ridiculous.

German science, German technique, German organization, and the adaptation of the German industries, regarded as makeshift by the British, triumph in irresistible victory over all difficulties which the German people are made to meet. This great success of ours is the more noteworthy in that, since the beginning of the war, our iron industry has been hindered in increasing degree by the constantly increasing legal restrictions and the limitations to its mobility caused thereby.

The fact cannot be gainsaid that the foundations for the maintenance of our steel industry on its present scale will continue unimpaired, even should the war last an innumerable term of years.

THE FRENCH STEEL INDUSTRY.

As to the French iron industry, it is conceded that of the normal output not less than 85 per cent is in German-held territory. On the other hand, that country can draw on the iron-ore deposits of Normandy and the Pyrenees as well as bring ore in on the Mediterranean, especially from Algiers and Spain. By this means without doubt France can operate her remaining blast furnaces and steel works, especially those with open-hearth furnaces, and produce, even under the circumstances, sufficient material for war needs, so that the plants in central France near Paris and those on the sea coast can operate.

Commenting on the exceptions taken to his estimates of the amount of France's coal in German hands (65 per cent), published in *The Iron Age* of March 18th, 1915, Dr. Schrödter says:

Official estimates place this year's coal output of France at the most at 18,000,000 metric tons, against 40,000,000 tons in normal times. Besides this the usual imports from German and Belgian sources of 10,000,000 tons are lacking. The supply thus falls short of the normal annual need of 60,000,000 tons by not less than 32,000,000 tons, which England should supply, though normally it exports only 10,000,000 tons to France. While the price of coal from northern France is artificially held at 28 francs per ton, more than 52 francs must be paid for the imported coal at all ports. It is evident that the question of coal is a "burning" one, that it is France's weightiest industrial problem, and hence the cry for state help is heard.

A strong movement is on in France to bolster up the export trade by politically and industrially organized measures, but in the meantime France's exports have fallen off considerably. The official figures, recently made public, show the decrease in iron and steel manufactures in 1914 to be 50 per cent from the total of 1913. The exports for 1914 are about equal to those of the first seven months of 1913. Exports of scrap, however, have doubled, evidently because of Italian demand.

THE BRITISH SITUATION.

In England the disorders in industrial operations resulting from the war have constantly increased in the year. Though the official data of the output of mines and iron and steel plants are not yet made public, nevertheless we know with certainty that the coal output is nearly 3,000,000 tons per month less than that of normal times. The recent strike of the Welsh miners has caused a decrease of at least 1,000,000 tons.

The production of pig iron has had to battle with constantly increasing difficulties. A picture of these can easily be drawn because the freight from Bilbao for iron ore has risen three and four times the normal rate. The exports of iron and steel manufactures, which were to absorb the German field, have not realized this expectation, but have shown an almost uninterrupted decline, which in the war months from August, 1914, to June, 1915, was 41.1 per cent from those of the same period of the previous year.

THE AMERICAN STEEL INDUSTRY.

In the United States the railroad reports, the number of bank failures as well as the complaints as to unemployment indicate that the entire industrial life has not improved, as was assumed by the Chauvinists who hoped for great advantages as a result of the elimination of German world competition. The production of pig iron, which in August, 1914, was 65,393 tons per day, in December had decreased to 49,678 tons, but in May, 1915, it had advanced to 74,180 tons per day, and in June to 80,160 tons.

It is astonishing, however, that the effect of the flow of orders for war material, which our enemies have showered on American plants and which have given rise to many new expansions, has not been more marked on the general current of that country's iron industry. While on the one hand the war industries have made great gains, on the other hand American industrial life has suffered enormously. It can be said to-day with certainty that the hemming in to which Germany is subjected by England's blockade will lead to a lasting falling off from our former large imports from North America, among which oil and copper may be mentioned. A later reckoning will show whether the present gain in war materials may not be at the cost of lasting damage to American exports to Germany.

* From The Iron Age.

The Sidereal Universe—II*

Theories Regarding Its Constitution, Structure and Motions

By J. S. Plaskett

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2078, Page 275, October 30, 1915

RUSSELL summarizes the facts which he has collected, and which appear to be well substantiated, as follows:

1. The differences in brightness between the stars of different spectral classes and between the giant and dwarf stars of the same class do not arise—directly, at least—from differences in mass; indeed, the mean masses of the various groups of stars are extraordinarily similar.

2. The surface brightness of the stars diminishes rapidly with increasing redness, changing by about three times the difference in color-index, or rather more than one magnitude, from each class to the next.

3. The mean density of the stars of classes *A* and *B* is a little more than one tenth that of the sun. The densities of the dwarf stars increase with increasing redness from this value through that of the sun (1.44) to a limit which cannot at present be exactly defined. This increase in density, together with the diminution in surface brightness, accounts for the rapid fall in absolute or intrinsic luminosity (about seven-fold from one spectral type to the next) with increasing redness in these stars.

4. The mean densities of the giant stars diminish rapidly with increasing redness, from one tenth that of the sun in class *A* to less than one twenty-thousandth that of the sun for class *M*. This counteracts the change in surface brightness, and explains the approximate equality in luminosity of all these stacs.

5. The actual existence of stars of spectra *G* and *K*, whose densities are of the order here derived, is proved by several examples among the eclipsing variables, all of which are far less dense than any one of the more numerous eclipsing stars of "early" type, with the sole exception of Beta Lyræ.

A little consideration enables us to see that these facts deduced by Russell from reliable data and which, so far as I know, are incontrovertible, form very strong evidence for the second theory of stellar evolution. In no other way than by a scale of ascending and descending temperatures can the presence of giant and dwarf stars of type *K* and *M* be explained. This may, perhaps, best be seen by tracing the evolution of a star from the nebulæ according to the second hypothesis. As the condensation of the nebula, which we may suppose extraordinarily extended, is of a very low density, lower than we can obtain in the highest vacuum and at a low temperature, we have the volume diminishing, the density and temperature increasing until the star becomes visible, a very red type *M* star of low density of the order of one twenty-five thousandth of the sun, a giant star of *M* type. As condensation proceeds, the volume continues to diminish, the density and temperature to increase, the loss in surface area being about compensated by the increase in surface brightness. Thus, we have giant stars of types *K*, *G*, *F*, *A* and *B* produced, the density temperature and surface brightness increasing rapidly. For example, from *M* to *B* the density has increased from about one twenty-five thousandth to one tenth the sun, and the temperature has risen from about 3,000 degrees to 20,000 deg. Cent. But condensation still proceeds, though not so rapidly, and the loss by radiation begins to overpower the gain of energy by condensation. The temperature begins to fall and the star now proceeds in the reverse order, back through *A* to *M*. But in this stage the density is increasing and both volume and surface brightness diminishing, and, hence, the absolute magnitude diminishes rapidly, exactly as shown by Russell, and we have the dwarf stars of the later types. After passing through the *M* stage, the star soon becomes invisible. This is the development followed by the more massive stars. Stars of less mass do not reach so high a temperature and do not get beyond the *A* type or even the *F* or *G*, while bodies of mass less than one tenth of the sun may not become visible at all. This also is very clearly shown by the data collected by Russell, who shows that the *B* type stars on the average have about ten times the mass of the sun, and are all giants.

It will thus be seen that many arguments may be adduced in favor of both theories, and it is possible, of course, that both may be true. A number of questions may be asked which are difficult to answer from either theory. For example, in the first theory, how can the great gap in temperature between the nebulæ, presumably not far from absolute zero, and the *B* stars, at 20,000 deg. Cent., be accounted for? Surely this difference in temperature cannot be bridged without some visible evidence appearing in the universe. Again, in the second theory, what becomes of the nebulium, helium and hydrogen shown in the gaseous and planetary nebulæ and so prominent in their spectra, if the next stage is a late *M* star with no evidence of the first two substances, hydrogen relatively weak, and myriads of metallic lines?

I will put one more question and then pass on to a brief summary of recent additions to our knowledge of the structure of the universe. Is it not possible that the order of procedure of development is different, depending on the character of the nebulous material? The relation between the gaseous and planetary nebulæ and the apparently continuous development to Wolf-Rayet *O* and *B* type stars has been shown by the work of Nicholson and Wright already reviewed. But the great majority of the visible nebulæ in the sky do not give a gaseous spectrum, but apparently give a continuous spectrum, or one of some similarity to the sun. May not the order of development from these nebulæ or from those which are quite invisible to us follow the lines laid down by Russell? There are many other interesting and fruitful lines of investigation concerning the structure and motions of the universe along which marked progress has recently been made; but time will not permit me to more than briefly touch upon some of them. One of the most important of these is the question of absorption of light in space, for evidently upon it will depend our measures of the extent of the universe. If there is an absorption of the light in coming from the distant stars, then our statistical calculations, based on the numbers and relative distances of stars of different magnitudes, will be in error, and our visible universe will be smaller in extent than we had supposed. The question of this absorption has been attacked from many sides by different investigators, and the general conclusion seems to be that there is an absorption due possibly to the presence of invisible nebulous matter, but that this absorption is very small, and will only have an appreciable effect on the magnitudes of stars at distances of some thousands of light-years.

The question of the extent of our universe and its general form and dimensions has been attacked within the past year by three investigators, using different material. Walkley, in a paper before the Royal Astronomical Society, from data obtained principally from the *B* type stars, shows that our sun is not central with respect to the Galactic plane, that it is situated about two degrees to the north of this plane, and that it is nearest to the portion in which Cygnus is situated, being distant from the boundary about 5,000 light-years in this direction, and about 6,000 toward Argo. Russell and Shapley in the December number of the *Astrophysical Journal*, as a result of a study of the distribution of the eclipsing variables, have found that a considerable majority of these objects (almost all of those of short period) lie within a region bounded by two planes 1,000 light-years apart and parallel to the Galactic Equator whose median plane passes 100 light-years south of the sun, the latter in exceedingly close agreement with Walkley, whose figures given above make it about 130 light-years. Almost all the remainder of these stars lie within 500 light-years on each side of this region. Within this region, the stars extend in all directions to the limit of investigation. If space is transparent this limit is 8,000 light-years. A plausible amount of absorption cuts this down to about 4,000 light-years.

Dyson has investigated the distribution of the stars contained in Carrington's Circumpolar Catalogue and finds:

1. Yellow stars are the nearest to us, 80 per cent of them being between about 300 and 1,600 light-years, 10 per cent being nearer than 300, and 10 per cent farther away than 1,600.

2. As we go from the yellow to the blue stars, or the orange and red stars, the distance increases.

3. The red stars are at great distances averaging over 3,000 light-years.

4. The stars vary greatly in intrinsic brightness, the red stars being especially luminous and averaging 100 times as bright as the sun.

5. Of all the stars down to the eleventh magnitude, about 95 per cent are more luminous than the sun.

6. When the luminosity of the stars in a given volume of space is considered, there are far more faint than bright stars.

7. Evidence has been found that the stars thin out very materially at great distances away from the sun.

The general agreement between these and Russell's conclusions about the absolute magnitudes of the stars is very good, and, indeed, the agreement between the three determinations of the dimensions and form of our sidereal universe is remarkable. They point to the universe as having a diameter of from 10,000 to 15,000 light-years, a thickness of some 2,000 to 3,000, and with our sun not quite central in it. Not many additional data in regard to the motions of the stars in this universe have lately appeared. The two-stream hypothesis, supported by Kapteyn, Eddington, and Dyson, seems to be fairly well substantiated, and may be plausibly explained on the supposition that our universe is composed of two separate systems interpenetrating one another. Quite recently, Turner has brought forward the suggestion that the two-drift system may be explained by orbital motions of the stars in the universe, those on one side of the center appearing to have a preponderance of motion in one direction as those on the other side would have in the opposite direction. In this connection, Jeans has computed that the directions of the stars in an orbital motion of this character would not be appreciably deviated by the approaches of neighboring stars. The probable deflection of the path of a star due to encounters is only about one degree after three thousand million years. That there may be other systems besides our own universe is suggested by Herzsprung, who finds a distance of 30,000 light-years for the small Magellanic Cloud if space is transparent. If, at this distance, it would be about a thousand light-years in diameter, and evidently a small affair as compared with our own universe. The Andromeda Nebula gives a solar-type spectrum, and if a star cloud, must be at the same order of distance. The very high velocity found by Slipher, three hundred kilometers per second approach, is considerably higher than anything in our own system except two or three isolated stars, while he further states that some of the other spirals have even higher velocities.

It will be seen that many wonderful avenues of research are being opened up, and new viewpoints concerning the universe are being suggested by these recent developments in astronomy and allied sciences. But all these investigations point to the great need of yet more and more information as to the motions and distances of the stars. It is now fairly well known exactly what information is needed to most usefully further these various lines of research, and it is the province of astronomers to furnish these data as soon as possible. The new telescope that our country is installing should be able to take an important part in supplying this information, and should materially help in the solution of the fundamental problem of astronomy—the constitution, structure, and motions of the universe.

* President's address at the annual meeting of the Royal Astronomical Society of Canada. From the Society's *Proceedings*.

A Comparison of Steam and Electric Locomotives

THE great electrification project of the Chicago, Milwaukee & St. Paul Railway on one of the western mountain divisions of its lines is an experiment of far-reaching importance in railroad development, and the following details in relation to the first of the big electric locomotives that will be used, which has just been delivered, will be of general interest, especially in comparison with the heavy steam locomotives of the Mallet type used in similar service.

	Mallet.	Electric.
Total weight	555,700 lbs.	564,000 lbs.
Rated tractive effort	76,200 lbs.	85,000 lbs.
Rated tonnage on 1 per cent grade	1,800 tons	2,500 tons
Speed with full tonnage on 1 per cent grade	8 to 10 m.p.h.	15.75 m.p.h.

A tractive effort of approximately 135,000 pounds is available for starting.

The electric locomotive is 112 feet long over all and the Mallet is 90 feet 1¾ inches. The total horse-power of the electric on continuous rating is 3,000, and it will develop 3,440 horse-power for one hour.

The same type of locomotive will be used for both passenger and freight service, the only difference being the gear ratio, which is 4.56 for passenger and 2.45 for freight. These locomotives are built in two sections, resembling an ordinary baggage car, as this arrangement provides a joint in the middle that enables it to take curves. There are eight pairs of driving wheels, four to each section, and each axle is driven by a motor of 430 horse-power. The front and rear ends of the combined machine are carried on four-wheel bogey trucks.

A District Sanitary Disposal Plant*

A Model Collection and Disposal System for City Waste Material

By Flora Spiegelburg

In order to make the Model District a *real model* of sanitation and economy, it should not only include the latest perfected disposal system by means of incineration, but the mixed collection of ashes and garbage. It should also eliminate the fly and disease breeding dumps (covered ones as well as the uncovered), scows, and the pier for the collection of dead animals and condemned food.

It is now a generally accepted fact by all progressive sanitarians that a mixed collection is dustless, odorless and flyless on account of the disinfecting qualities contained in the ashes. It will, therefore, prove the most effective means of cleaning up the congested districts; by eliminating the fly, roaches, rats and mice, the spread of all contagious diseases will be greatly lessened.

According to an expert there are a million germs on a fly's head; surely this is the strongest plea for a mixed

Administration building of the incinerating plant at Fuerth, Bavaria, surrounded by flower, fruit and vegetable gardens.

collection—the elimination of fly and disease breeding dumps of all kinds and the incineration of all burnable wastes, in order to have a spotless, flyless city.

Judging from the report of the Model District, it provides only for a refuse collection method. Operation and maintenance necessary for this collection as well as the many street cleaning activities, will doubtless cost the city a large sum of money.

In most European cities, in Germany and Holland in particular, the "Zone Incinerator Plant System" has for years proven successful and self-supporting. In Rotterdam, after running the plant, crushing the slag, etc., the excess power is used to supply the entire electric car system of the city and there is still sufficient power for the proposed motor trucks. The power generated here would prove so even in a much greater degree, because the American garbage contains much more grease, and the ashes 20 to 30 per cent more heating quality, and the entire output is three to four times as large as in any European city.

On account of the low percentage of heating qualities in the mixed collection of ashes and garbage at Frankfort-am-Main, it was found necessary to erect the incinerator on the same grounds with the sewage disposal plant, and in order to make it self-supporting the oils and grease obtained from the sewage had to be burned with the refuse.

Here, besides ashes and garbage to be used as fuel there is a large amount of condemned food, dead animals and trees, rejected piles, useless lumber and equipment from all the departments, infected bedding, carpets, manure, street sweepings, a great quantity of broken boxes, barrels, furniture, small burnable trade wastes and an amount of rubbish which is very great.

The power that could be generated from this vast amount of fuel could be used to light, heat and run the entire zone plant, crush the slag or residue and run the waste disposal plant. The excess power should be turned into electric storage batteries for the use of all the various motor cars and trucks for the disposal plant, as well as all required by the Department of Street Cleaning. With the exception of the three summer months there should be still sufficient power to supply the storage batteries for many of the municipally-owned cars and trucks of the fire and health departments or any other situated in that particular zone.

A second source of revenue, which if economically managed should be very large, is the vast amount of slag or residue derived from the incinerated refuse, to be sold either for concreting purposes, road making or made into bricks for sewer lining or paving. This vast amount of material for building or road making purposes could also be called for daily by boat, or used in that particular zone, thus cheapening cost of haulage.

The vast amount of waste materials, such as paper, rags, tin cans, scrap iron and other metals, scrap leather, rubber and other trade wastes, should be baled. The enormous amount of good boxes, barrels (selling from 5 to 25 cents), bottles (milk at 1 cent) should be sold by yearly contracts to the highest bidder. In order to avoid accumulations and keep the zone spotless and flyless, the contractors should call for them all daily, and as much as possible by boat, thus lessening expense of haulage. As the disposal plant faces the river, it will doubtless prove not only the cheapest way but avoid much congestion in the streets, just as the congestion and haulage of all the refuse, dead animals, condemned food and all other waste materials enumerated above will be greatly lessened by bringing everything in that particular radius to the "Zone" to be finally disposed of, besides freeing our beautiful river-front from many fly and rat-ridden pest holes.

A few examples of highest efficiency in sanitation, which eliminates the flies, rodents, dumps, scows, piers for dead animals and condemned food: I personally witnessed the collection of refuse twice last summer in Fuerth—acknowledged to be the most perfect system in Europe. There the Ochsner system of covered receptacles and motor trucks has been successfully adopted. It is absolutely dust, odor and fly proof because neither receptacle nor wagon is uncovered during the process of collection and on arrival at the destructor a traveling crane transports a division of the motor truck directly to the oven, the bottom is opened and the refuse drops into the oven of the incinerator.

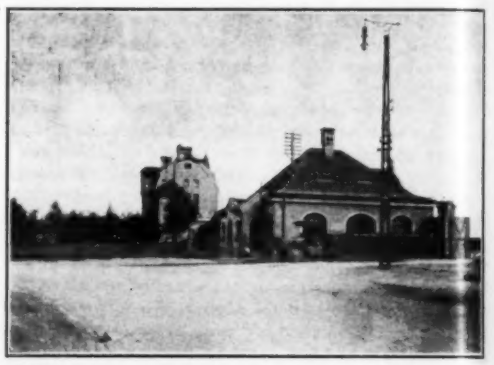
According to the proposed "Zone Plan," if two men with the motor truck started to collect ashes and garbage at seven o'clock, before eight o'clock they would be able to deposit their load at the destructor and fifteen minutes later the incinerated refuse—now slag or residue—should be cooling in the yard, opposite the destructor, before nine o'clock, ready for the crushing process, thus taking less than two hours' time for the final disposition of the refuse.

At present, in accordance with the rules of the Health Department, the scows may not remain longer than twenty-four hours loading at the dump, but it often happens that if not filled, the scow is detained more than two days; consequently in warm weather the stench is insupportable. Meanwhile millions of flies breed and feed (besides numberless rodents) on the decaying garbage, condemned food, diseased animals and germ-laden waste materials.

But in comparison to our present unsanitary method of collecting and disposing of dead animals and condemned food the Zone Plan offers the highest, greatest and most desirable efficiency, namely, if a horse drops dead of glanders, or spoiled food has been condemned, the Health Department 'phones to the Inspector of the Zone Plant; he immediately sends his animal truck, or should it be on duty, it cannot be away more than half an hour within the radius of the Zone. So now again it may be safely stated that with few exceptions, in less than one hour after the dead horse or any other animal, or condemned food, has been incinerated and is cooling in a sanitary, flyless, odorless state, ready like the other refuse to be added to the slag and made into bricks for paving or other purposes. All infected bedding and clothing can be disposed of just as quickly and cheaply.

In conclusion I venture to predict that possibly sufficient revenue may be obtained from the power generated, the sale of the slag and various waste materials to make the incinerator more than self-supporting. Add to this the money saved from the disposal of dead animals and numberless other expenses at present. Also consider the revenue diverted to the city from the use of the piers ($10,000 from each borough) for the disposal of dead animals and condemned food.

Naturally, according to the vast amount and quality of refuse and waste materials collected in each Zone, it must differ correspondingly in its amount of revenue, but

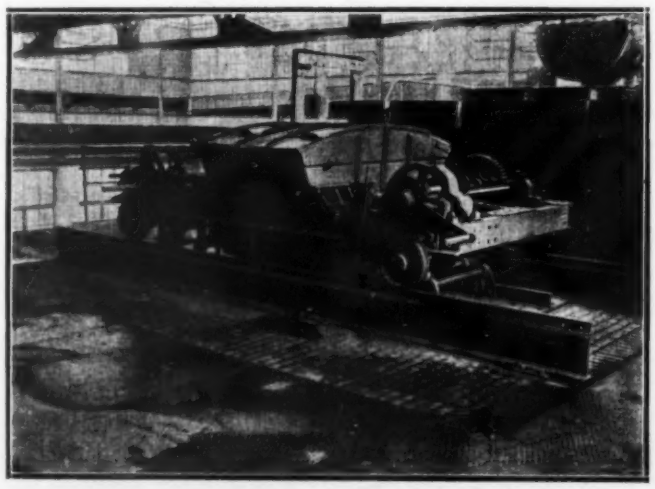


Weighing motor refuse wagon at entrance to incinerating plant.

since it will go directly into the treasury of the Department of Street Cleaning, it will certainly solve the much-to-be-desired problem of helping to place the department on a self-maintaining basis, or in other words, cut down the present expenses as much as possible.

But in order not to be misunderstood in offering this carefully laid out plan which includes every modern improvement for the collection and disposal of all city waste materials, the administration thereof, as well as sanitary working facilities for all laboring men at the Zone and the entire street cleaning force of that particular zone, I would suggest testing *only one* sanitary and profitable Zone incinerator plant; this should be included in or added to the present proposed Model District, adapted to its requirements so that it might prove a *real model*, for the disposal system is the root of the evil and should, therefore, be considered before the collection method on account of greater sanitation.

To further perfect the sanitary regulations of the Model District, besides the dustless, odorless and flyless mixed collection and metal-covered motor trucks, the receptacles for the street sweepings should have the same non-detachable covers as those for the refuse. All waste materials should be covered; each house should be provided with a shelter or place to keep them, in order to keep refuse cans off the sidewalks.



Section of motor truck body over oven of destructor, ready to be emptied into the incinerator.

*Cuts by courtesy of *Real Estate Bulletin*.

Myrtle Wax of Commerce

A Valuable Natural Product That Has Been Overlooked

It is not encouraging to note that we are largely dependent on foreign countries for a good many crude products which could be produced in this country by the proper utilization of our resources. The greater part of our crude drugs come from Europe. For silks we are largely indebted to foreigners, and in like manner we draw from foreign sources a great portion of our supplies of dyes and tanning materials. There is a wide field for enterprise in the supply of such minor farm and forest products as nuts, beans, oils, starches, etc. As for instance, we may take the article of vegetable wax for which there is a considerable demand. Why should we pay practically a million dollars annually for this product to foreign countries, when it can be obtained so easily in many parts of this country? There is a great demand for wax, not only in the United States, but Europe pays annually millions of dollars for this article.

Vegetable wax is obtained from different families of plants which are widely distributed over the earth. There are several species of palms growing in the tropics which yield commercial wax in great abundance, but in this country we have the wax myrtles which are *par excellence* the wax-producing plants. The most important one of these is the bay berry or myrtle berry (*Myrica cerifera*) which is common from Newfoundland southward to Florida and Texas. Another species known as the sweet gale or bog myrtle (*Myrica gale*) is found principally in the New England and Great Lake States. These two species are very similar in the amount and character of wax they produce. They are said to yield wax of such a superior quality that they deserve a high rank among the wax-producing plants. In the trade the product is known as myrtle wax.

Wax myrtle planted on dunes near Provincetown, Mass., for holding the sand in check.

The preparation of myrtle wax from these bay berry bushes is long since beyond the experimental stage and the results that have been obtained are very encouraging. There is an ample opportunity for farmers and others in many sections in the Atlantic and Gulf States to add to their income by the collection of bay berries which contain the wax. There are on a good many farms along the Coast waste places or low areas on which bay berry bushes grow very abundantly and the berries could be gathered in paying quantities. According to the U. S. Dispensatory (19th edition) the berries are now collected in New Jersey, North Carolina, and New England and particularly in Rhode Island. In parts of England and in South Africa the collection of bay berries of other species is an important industry, but in America these apparently smaller opportunities are often lost sight of in the general desire to grow crops on a large scale. Americans are apt to overlook the combined results from many small crops that can be handled with comparatively little expense. The European farmer keeps a strict account of these, and in the aggregate reaps a rich reward for his thrift.

The wax produced by the bay berry bushes occurs on the fruit or berries as a thick coating of a white waxy resinous secretion. The fruit consists of a small nut or drupe about the size of a small pea. These berries, as they are commonly called, are growing very abundantly on the small shoots of the last year's growth and can be easily collected by simply rubbing them off with one hand and holding the branch with the other. The person gathering the berries should have a suitable basket or container strapped to his belt so as not to be bothered too much with the handling of it. If the berries are large and fairly abundant, one man can gather enough berries to realize him from twenty-five to thirty pounds of pure wax. About four pounds of berries yield one pound of wax.

The method employed in this country for procuring the wax is by boiling the berries in a copper or brass kettle for some time. Iron pots are found to darken and cloud the wax. The method of separating the wax from the berries is extremely simple. The latter are boiled in water for a sufficiently long time, but in order to facilitate the separation of the wax, which forms a pellicle on the surface, the berries must be stirred during the boiling. After all the waxy particles are removed from the berries the wax, which rises to the surface, is skimmed off and strained through a coarse cloth in order to free it from impurities. The process of melting the wax and straining may be repeated until it is perfectly pure. After the wax is rendered sufficiently pure for the market it is cast into large cakes and sold at prices ranging from eight to fifteen cents per pound, depending upon the use to which it is to be put.

Myrtle wax is commonly used as an adulterant of bees' wax. It is often substituted by apothecaries for bees' wax in the foundation of plasters and it is used also in the preparation of tapers and candles. It has been popularly employed in the United States as a remedy for dysentery with alleged great advantage. The bark and root of the wax myrtle bush are also said to possess valuable medicinal properties and are so employed.

A dense hedge composed chiefly of wax myrtle, near Provincetown, Mass.

Recent Studies in the Dynamics of Living Matter

In Prof. Jacques Loeb's book, which bears the title set at the head of this short article, there is a well-known chapter on the heliotropism, that is to say, on the tendency of plants to turn toward the light, and on other kindred phenomena manifested both in plants and animals; for the polypes of a hydroid colony such as Eudendrium, or the tube-dwelling worms, such as Serpula or Spirographis, also bend toward the light, and if they be illuminated by a single beam they grow steadily in the direction of its rays. It is characteristic of the plant (or rather of the green plant) that it represents a peculiar type of machine which is capable of turning radiant energy into chemical energy, and so ultimately into mechanical work; and in the case of the plant, "the permanency of this kind of machine is guaranteed by the presence of an automatic arrangement, whereby their stems turn toward the light." So Loeb is inclined to read into this phenomenon what we might call a modified teleology, such indeed as, in one form or another, refuses to be kept out even of our most modern biological speculations.

In the chapter already alluded to, published some nine years ago, our knowledge was said to be very scanty as to relative heliotropic efficiency of the various parts of the spectrum, little more being known than that the more refractive rays, the green, the blue, and the violet, were more effective than the yellow and the red. "There exists thus, apparently," said Prof. Loeb, "a division of labor, the longer light-waves accelerating assimilation, and the shorter waves accelerating heliotropism"—just (we might say) as there is obviously a "division of labor" between the rays which illuminate and those which warm us.

Two of Prof. Loeb's recent papers (by Dr. H. Wasteneys and himself—Pr. Nat. Acad. of Science, January, 1915, and *Science*, February 26th, 1915) are devoted to the question of the identity of heliotropism in plants and animals, and thereby to an inquiry into the particular wave-length of light to which, in one case or another, they are most sensitive. Instead of exposing the organisms to the solar spectrum itself, as had been done in earlier and simpler experiments, the writers (using a carbon arc spectrum) allowed the light from particular portions of it to pass through narrow slits, and then reflected it in a monochromatic beam upon the subject of their experiments. They soon arrived at the simple but very remarkable result that there are two particular regions of the spectrum the rays of which are especially effective in causing organisms to turn, or to congregate, toward them; these regions lie (1) in the blue, in the neighborhood of a wave-length of 477 $\mu\mu$, and (2) in the yellowish-green, in the region of $\lambda = 534$ $\mu\mu$; and these two wave-lengths affect different organisms, with no very evident relation to the nature of these latter. Thus, the blue rays (of 477 $\mu\mu$) attract the infusorian Euglena, the hydroid Eudendrium, and the seedlings of oats; while the yellowish-green rays (of 534 $\mu\mu$) in turn affect the protozoon Chlamydomonas, the little water-flea Daphnia, and the larvæ of barnacles.

These facts add a quality of precision to many older and vaguer observations, for instance, to Paul Bert's discovery (in 1869) that Daphnia swims toward the light in all parts of the visible spectrum, but most rapidly in the yellow or the green. The particular wave-length of 534 $\mu\mu$ is especially remarkable, because it coincides with a determination by Trendelenberg that the visual purple of the rabbit's eye (which is not affected by red and very little by yellow light) is bleached most rapidly by light the wave-length of which is 536 $\mu\mu$. It would seem, according to Loeb, that among the lower organisms we have to deal with two separate photosensitive substances, which determine their heliotropic reactions; that these are distributed without regard to the systematic boundaries, even between plants and animals; and that one of the two, occurring even among very lowly organisms, has characters similar to, and is perhaps identical with, the visual purple of the highest type of eye.

In another paper (*Science*, November 6th, 1914), still dealing with the effects of light, Prof. Loeb relates some remarkable observations on the action of ultra-violet rays upon unfertilized eggs, adding by these new experiments a curious detail to the many facts regarding artificial fertilization, by chemical or physical means, which we associate with his name as their prime discoverer. On the ground that ultra-violet rays are known to have a sterilizing effect, that is to say, to be capable agents in the destruction of cell-life, and that, according to Loeb's own experiments, the very substances which induce "cytolysis" in the living cell are also capable (under proper conditions) of producing artificial parthenogenesis, Loeb thought it likely that these rays would also prove to be effective stimuli, under the appropriate conditions, of parthenogenetic development. He exposed the unfertilized eggs of a sea-urchin for ten minutes to the light of a quartz mercury arc lamp, and found that the majority of the eggs formed "fertilization membranes"; when kept cool they further proceeded to segment, but ere long perished; an addition of hypertonic sea-water, however, enabled them to develop into larvæ, though few advanced beyond the gastrula stage. It was remarkable that a cover-glass, 0.1 millimeter thick, was sufficient to prevent all action on the part of the light, a fact which bears closely on the wave-length of the rays which produced the action.

The discovery here mentioned is certainly interesting as a specific case of the effect of radiant energy on living protoplasm; but its precise degree of interest turns largely on the importance which we may attach to the formation of a surface-membrane as an essential preliminary to the development of the egg. According to Loeb, this phenomenon is of supreme importance; for the question why an unfertilized egg cannot grow, and why a fertilized egg can grow and divide, depends, according to him, entirely on the condition of the surface layer of the egg; the nature of this cortical layer determines whether the egg be in an active or a passive phase, and the essential factor is a change in the rate of oxidation, to which the condition of the cortical layer directly leads. "The forces which induce the egg to develop are, therefore, localized *at the surface of the cell.*" This is a somewhat hard saying, but in Prof. Loeb's hands it leads to many suggestive and stimulating reflections. The whole subject is discussed in his book on "Artificial Parthenogenesis, etc." (1913), and in a paper now before us, on the "Stimulation of Growth" (*Science*, May 14th, 1915).—D'Arcy W. Thompson, in *Nature*.

Commercial Glucose*

Its Constituents and Some of Its Many Uses

By George W. Rolfe

Most well-informed people know that in the early part of the last century Kirchoff was the first to describe a sugar made by boiling starch with dilute sulphuric acid, and that this sweet, subsequently found to be other than cane-sugar, was called "glucose" or "grape-sugar." Later it was termed "dextrose" when in the progress of science it became necessary to distinguish the individual from a whole family of "glucoses" which had been discovered.

Nowadays, most of us have heard of "glucose" as a commercial product of doubtful reputation. People look askance when glucose is mentioned. Confectioners and grocers make haste to deny that glucose ever appears in their products. Glucose is classed with harmful food adulterants, and has been called by pure food experts the "champion adulterant" of all. It has been depicted in cartoons as a devil with hoofs and horns. Glucose has also been called "mucilage," the implication being that it is only fit for postage stamps and not for human stomachs. This may be why many associate glucose with glue. The names sound alike and both are sticky, but the reasoning is like assuming that all gentlemen are gentiles. Glucose makes a rather poor adhesive, but one who is hard put for mucilage might so use it with indifferent success just as it is possible to use tapioca pudding, molasses or other sticky foods.

Turning to the advertising literature of the glucose manufacturers, we note that many eminent authorities laud glucose as most wholesome, that it is the principal sweet of fruits and one of the intermediate products of the digestion of starch in the human organism, is found in the blood—and similar statements, all of which, like the damning ones of some pure food experts, are "important if true."

Notwithstanding that annually between thirty and forty million bushels of Indian corn are made into glucose, comparatively few except those engaged in the numerous industries in which glucose enters ever see the product. The idea of the general public, professional as well as the laity, seems to be that glucose is mostly composed of grape-sugar, which is made according to the Kirchoff method by boiling starch and oil of vitriol and neutralizing the mixture with chalk. Many supposedly up-to-date cyclopedias make such statements.

Much of the ignorance concerning this important food product is due to the following facts: Pure commmercial glucose is practically unknown in household cookery, and so is not sold in a package convenient for household use. While it is in multifarious food products found on the grocers' shelves, it is rarely seen there in its original state. This is equally true of raw sugar. Years ago, raw open-kettle sugars were familiar to all New England housewives and were used by them in cooking. Raw sugars made by modern processes are used to some extent now in England and European countries, but nowadays few of the citizens of this country, outside of the sugar producing districts, ever see raw sugars, which are sent directly to the refineries in packages weighing several hundred pounds each and in a condition not fit for domestic use. Glucose, like refined sugar, is manufactured in comparatively few factories, and these of large capacity, for the manufacture of glucose requires a large outlay of capital and consequently large output. The cheapness of the product makes its manufacture profitable only on a large scale. This is equally true of sugar.

What is commercial glucose? In general appearance it is a transparent, very viscous syrup, often practically colorless, but usually of a light straw color, sweet, but with little if any other flavor. For this reason, glucose, like sugar, has been termed a "neutral sweet"—not neutral in the chemical sense—although such products are always chemically neutral within practical limits of testing—but so called because when pure they have no characteristic flavor other than sweet and will take any added flavor unchanged.

Glucose is not made by use of oil of vitriol and chalk, nor is glucose, in the ordinarily accepted sense of dextrose, its characteristic ingredient. The trade name "glucose," while well established by custom of years, is no more suited to the present product than is "chloride of lime" to bleaching powder or "hyposulphite of soda" to the commercial salt sold under that name. It is true that the basic process by which glucose is made from starch is on the lines of Kirchoff's original experiments, but the methods are quite different. The "starch milk," a suspension of the granules in water, is pumped into large pressure boilers of gun metal, and is cooked for about ten minutes with a few tenths of a per cent of hydrochloric acid (commercial muriatic acid) under a pressure of about 50 pounds of steam. The starch is not treated long enough by this process to convert it entirely into grape-sugar (true glucose), only about 20 per cent being produced. There is, in fact, less of the glucose sugars, properly so called, in commercial glucose than occur as natural ingredients of cane-sugar molasses, and far less than in honey, which is composed almost entirely of glucose sugars, nearly half of which is dextrose (grape-sugar), this being the sugar which separates out when the honey granulates.

Commercial glucose as now made contains less than 20 per cent of true glucose sugars, the rest being a mixture of malt-sugar (maltose) and dextrins, more or less in chemical combination in the approximate proportion of nine parts of maltose to seven of dextrin. In percentages of total sugars and dextrins, there are, in round numbers: maltose, 45 per cent, dextrose, 20 per cent, dextrin, 35 per cent, the proportions varying somewhat in different lots.

These three carbohydrates, *dextrose*, which is a true glucose sugar, *maltose*, belonging to the cane-sugar family, and making up nearly half of the total, and *dextrin*, a gummy ("colloidal") substance closely related to starch paste, compose over 99 per cent of the solid matter of refined commercial glucose. This composition has been found to be the most desirable for imparting to the product the properties most suited for a syrup which can be refined readily, and at the same time contain enough colloidal material to prevent its crystallizing at any concentration. This colloidal matter also renders the syrup capable of dissolving considerable amounts of cane-sugar without crystallization. Such a product is peculiarly valuable in the preparation of syrups, candies, preserves, and jellies, quite apart from its use as a sweet. It also contains nearly the maximum amount of malt sugar that can be produced by such a process.

The rest of the dissolved substance of commercial glucose consists of 0.3 to 0.5 per cent of mineral matter, mostly composed of sodium chloride from the neutralization with soda of the hydrochloric acid used in the manufacture, sulphites which are added at various stages, phosphates and other salts from the natural mineral matters present in minute quantities in the starch or coming in part from the bone-black used in the refining process. There is also about 0.08 per cent of nitrogen, corresponding to five or six times its weight of organic substances from the gluten left in the starch. Much of this nitrogenous matter is not gluten, but simpler organic compounds resulting from the action of the acid (used to convert the starch) on the gluten. These nitrogenous matters have much to do with the quality of the glucose, and it is on this account that they are of peculiar importance, although present in minute amounts. The impurities from the gluten which are less acted upon by the acid, the "albumoses," give trouble to the candy manufacturer by causing foaming in his kettles, while this property is the joy of the brewer. Those gluten substances which are changed further by the acid, the "amino bodies," tend to make the glucose darker and also impart a flavor which, though barely perceptible, is disagreeable —bitter or fishy. Manufacturers used to correct the objectionable effects of these impurities by the addition of sulphites to the glucose, but this was but a temporary expedient and undesirable in a food product. Glucose has been much improved in recent years by practically eliminating the effect of these impurities by more efficient purification of the starch used in its manufacture.

The glucose process does not end with the acid treatment of the starch and the neutralizing, as at this stage the dilute syrup is far from pure, containing oily matters from the corn, some undecomposed gluten and other impurities, mostly in suspension. This liquor before it is concentrated to a syrup of about 80 per cent solids undergoes a refining with bone-black closely resembling that of cane-sugar, the apparatus being practically identical—filtering through bags and bone-black filters—but in the case of glucose all impurities affecting the quality of the syrup have to be removed or destroyed, as there is no purification by crystallization.

Hence glucose, like granulated sugar, is one of the purest food products in use, however pernicious the properties that may be ascribed to it.

Space does not allow a detailed description of glucose manufacture, which is of great interest, owing to the numerous by-products which are made, and also because, while glucose is the chief in output, its manufacture is only one of many starch products carried on at the same time.

The following table, taken from an advertising circular of a manufacturer, shows in a concise way how the different parts of the corn kernel are utilized:

Parts of Corn Kernel.	Composition	Products.
1—Germ	Oil and oil-cake	Corn oil, corn oil-cake, corn oil meal.
2—Endosperm (body of the corn)	Starch	Dry starches, dextrins, and, by conversion, corn syrups (glucose) and sugars.
	Gluten	Gluten feed.
3—Hull	Bran	Gluten feed.
4—Water added for steeping	Soluble substances of corn	Gluten feed.

The oil is used principally for soap and for making vulcanized products used for rubber substitute. The oil-cake and meal from the cake are used as cattle feed. The gluten and bran from the starch, mixed with the soluble matters extracted by the water used to soften ("steep") the grain before grinding, is made into "gluten feed," also for cattle. All these are valuable by-products for which there is a good market. The starch in a moist state, known as "mill starch," is the raw material for making the various goods which are sold under the names of "glucose" ("corn syrup"), "corn-sugar" ("grape-sugar"), the latter a hard product which is largely composed of dextrose, but never known in trade as "commercial glucose" and little used as a food product; "dextrins," true adhesives which are usually made by roasting starch and entirely different in characteristics from the dextrin ingredient of commercial glucose; besides numerous "dry starches" used by laundries, confectioners, and in many other industries, as well as for household purposes.

At present prices commercial glucose, a syrup containing about 80 per cent of the pure carbohydrates in solution, sells at about 2¼ cents per pound (26 to 28 cents per gallon), or at about 2.7 cents per pound of actual dissolved substance. Is its sole use that of an adulterant of better food materials, as some food reformers claim? Is glucose used to adulterate our ordinary grocery sugars?

It is well known in the history of the industry that some thirty years ago a Chicago concern spent some millions of dollars and much valuable time in trying to adulterate fine-grained white sugars with solid grape-sugar of high quality, made from starch, but the attempt failed miserably, simply because the stuff would not stay mixed and the grains "set" in a solid mass after a short time. In years gone by glucose was also much used to mix with cheap, poor-grade molasses, making a brighter, more attractive product which, so improved, could be sold at the price of higher grade molasses. This form of adulteration is so easily detected that it is rarely resorted to in these days of pure food legislation. The last case which came to the writer's notice was one of a New York molasses dealer who was heavily fined for having a few per cent of commercial glucose in his molasses, although his defense was a plausible one—that the glucose was some accidentally left in the barrel, old glucose barrels being much used for tropical molasses shipments.

Glucose is now used in a legimate manner to mix with cane-sugar syrup in the proportion of 85 per cent of glucose to 15 per cent of syrup, a little salt and sometimes vanillin being added to improve the flavor. The cane-sugar syrup is usually refinery molasses ("barrel syrup"), which imparts the principal flavor. These mixed syrups are sold openly as glucose or "corn syrups," and as their flavor is superior to the original molasses there seems to be no reason why they are not wholesome food products for legitimate trade, even though some people there are who prefer the flavor of the syrups made from the natural cane juices and are willing to pay the higher price for such. Certainly such glucose syrups are preferable to the average grocery molasses, either from the standpoint of the epicure or the sanitarian.

Commercial glucose is used in large quantities in the manufacture of cheap jams and preserves. Apple cores and skins from fruit in its preparation for evaporation or preserving are the basis for most cheap jellies; the pectin substance and juice being extracted by the usual processes of jelly making and mixed with glucose and sugar forms a jelly material to which other fruit juices are added. The law requires such jellies to be plainly described on the label so that the consumer is informed that he is using a jelly made of apple and glucose with a fruit flavoring, and is at perfect liberty to buy the pure, glucose-free fruit product if he so prefers. What interests the public is: Are these cheap jellies unwholesome, or is there other reason why the man with the slim pocketbook should not buy them? This question is quite apart

* *From Science Conspectus.*

from whether they contain glucose or not, but deals with the soundness and wholesomeness of the ingredients used and the cleanliness of their preparation.

By far, the largest amount of glucose is consumed in the manufacture of candy, the peculiar properties of this syrup making it especially valuable in this industry, as has been explained. The requisite for most candy is that it should not "grain" (crystallize), and glucose, owing to its colloidal nature, is the most effective and wholesome substance to prevent this. The popular impression that glucose is used in candy-making because it is a cheap substitute for sugar and that its sole function is to give sweetness is only approximately correct.

How sweet is glucose relative to cane-sugar? Determinations of the sweetness of saccharine product are very unsatisfactory, owing to personal equation and also to the influence of the other mixed ingredients and even the physical condition of the substance tested.

Granulated sugar tastes sweet. Powder it in a mortar and it will taste less sweet. Owing to this fact it is hard to convince some people that powdered sugar is not adulterated, although this practice, easily detected, is practically unknown at present. A quarter of a grain of quinine mixed into a pound of granulated sugar is said to make it taste sweeter. Common salt in small quantities will improve the sweetness of cake and other sweet foods, as all cooks know. Raw sugars, even when they contain negligible quantities of the sweeter mother-syrups, taste distinctly sweeter than granulated sugar, although their actual sugar content is less. This is due to the salts and extractive matters in the raw product, and it is why many cooks sigh for the old-fashioned, open-kettle sugar, and even prefer the refiners' imitation goods to granulated sugar in making their apple pies.

Relative tests of the sweetness of cane-sugar and glucose (*dextrose*) have been made by dilution experiments on the pure sugars, but, so far as the writer knows, no relative tests of the sweetness of commercial glucose as now made have been published. Taking this value to be 0.5 for the solids in glucose, sugar at 5 cents is cheaper as a sweetner than glucose.

As a matter of fact, very little candy is made with glucose as the only sweet. Usually, candy contains 60 per cent or more of cane-sugar, the sweetening of the glucose being of much less importance than the other properties it imparts to the mixture.

It seems reasonable to infer that commercial glucose, rather than being a serious competitor of cane-sugar, has really increased the consumption of the latter especially in candies. Because of the great advantages from the use of glucose in candy-making, the industry has had an impetus which has greatly increased sugar consumption.

The relative wholesomeness of candies made from glucose and those made from cane-sugar has never been decided, and may never be. The dextrins of "glucose" as now manufactured are in great part in combination with the malt-sugar and seem in every way identical with the malto-dextrins obtained by the action of malt on starch, and are digested more in the intestines than in the stomach as compared with pure sugar candies. Whether this is an advantage or not, the physiologists must decide.

Glucose is extensively used in industries not making food products. It is used in cheap soaps, for "filling" leather and tanning extracts, and, as many of its uses in such industries are apparently for adulteration, such practices have no doubt added to its reputation as the "champion adulterant." As was pointed out in an article in a previous number of this magazine, on the industrial uses of sugar, the highly respectable beet-sugar of 99 per cent purity is used in Europe for precisely the same purposes, the choice between sugar and glucose as a "filler" being merely a matter of price. Cane-sugar has also been used extensively to "fill" coal-tar dyes and adulterate chocolate without having its respectability seriously impugned.

In view of the undoubted commercial importance of glucose as a food product it would seem as if its value in dietetics and food economics, as well as its relative wholesomeness, ought to be studied in the light of a proper knowledge of its special characteristics. To call glucose "mucilage," or to ascribe to it properties of a dextrose solution, is either ignorant or dishonest. So far as the use of glucose as an adulterant is concerned, it is the function of the pure food laws to protect the public from these practices, and such obviously are quite apart from the legitimate and open use of glucose, sugar, or any other cheap and wholesome food product as a satisfactory substitute for more expensive ingredients, and the propriety of such a substitute always will be its suitability for the purpose and its cost.

If legislation is appropriate for forbidding the extravagant claims of manufacturers and dealers as to the superiority of their food products, why not legislation to prevent irresponsible statements of "pure food" authorities which are condemnatory? Certainly, the one is as important for the public interest as the other.

Physiological Effect of Natural Gas

EFFECTS OF NATURAL GAS ON CANARIES.

THE artificial illuminating as of cities, made by the destructive distillation of coal and oil or by the action of steam on hot coke, contains from 8 to 10 per cent upward of carbon monoxide. In some cities the gas may contain as much as 30 per cent of carbon monoxide, and many deaths have been caused from its escaping and the user breathing it. On the other hand, natural gas contains no carbon monoxide or other poisonous gases, excepting hydrogen sulphide in occasional samples. But, to the author's knowledge, natural gas containing hydrogen sulphide is not used in any city. However, there are present in the natural gas used in many cities small proportions of the higher paraffin hydrocarbons, butane and pentane. These, if inhaled in sufficient quantity, exert an anesthetic action on the human system. It is generally known, for instance, that ordinary gasoline, which contains large quantities of pentane and hexane, will give many people a headache if inhaled in sufficient quantity and often has produced a condition similar to alcoholic intoxication. Methane, the chief constituent of natural gas, is physiologically inert. Perhaps the same can be said of ethane, but most likely propane has some effect and butane and pentane undoubtedly have. In most natural gas the proportions of butane and pentane are probably too small to have any decidedly dangerous effect on man.

In order to get some information on this matter some experiments were made on canaries. Various proportions of the natural gas used in Pittsburgh were introduced with pure air in a 10-liter bell jar and the effects noted. The results were as follows:

According to the foregoing table, the proportion of natural gas in air required to produce collapse in canaries is very large (65 per cent or more). With as much as 63 per cent collapse did not occur in one hour's time, although the distress was immediate. Distress was evinced by the canaries opening their bills and breathing rapidly and finally squatting on the perch in a lethargic manner. Some of the canaries were more resistant than others.

EFFECT ON CANARIES OF ATMOSPHERES LOW IN OXYGEN.

The results of these experiments indicate that as far as the action of natural gas on canaries is concerned it is largely a question of a deficiency of oxygen produced by diluting the air with natural gas. In investigations to determine the suitability of using small animals in mines to detect atmospheres dangerously low in oxygen, the results of which are described in Technical Paper 122[1], experiments were made to determine the resistance of canaries to low oxygen atmospheres produced by diluting air with nitrogen. The results obtained, as may be seen from the table following, show that the effect on the canaries is much the same as that of natural gas.

In conducting the experiments, atmospheres containing various percentages of nitrogen and oxygen were prepared in bell jars of 10-liters capacity. The nitrogen used analyzed 97.8 per cent nitrogen and 2.2 per cent oxygen. Three canaries, designated in the table as *A*, *B*, and *C*, were used in the Experiments.

[1] Burrell, G. A., and Oberfell, G. G., Relative effects of atmospheres deficient in oxygen on small animals and on men: Technical Paper 122, 1915.

EFFECT ON CANARIES OF BREATHING MIXTURES OF NATURAL GAS AND AIR.

Test No.	Natural Gas.	Air.		Carbon Dioxide.	Effect on Canary.
		Oxygen.	Nitrogen.		
	Per cent.	Per cent.	Per cent.	Per cent.	
1	76.9	4.8	18.2	0.1	Immediate collapse.
2	69.9	6.1	23.1	0.9	Do.
3	66.3	6.9	26.1	0.7	Showed immediate distress, but did not collapse in one hour's time.
4	65.8	7.1	26.9	0.2	Immediate collapse.
5	63.0	7.5	28.4	1.1	Showed immediate distress, but did not collapse in one hour's time.
6	49.3	10.6	40.0	0.1	Showed unsteadiness of movement for the first five minutes and was more or less drowsy during the exposure, which lasted one hour.
7	44.5	11.6	43.8	0.1	Do.
8	34.5	13.7	51.7	0.1	Only symptom in one hour's time was drowsiness and unsteady movement.

EFFECT ON CANARIES OF BREATHING ATMOSPHERES LOW IN OXYGEN.

Test No.	Canary Used.	Composition of Atmosphere.					
		At Beginning of Experiment.			At End of Experiment.		
		Oxygen.	Nitrogen.	Carbon Dioxide.	Oxygen.	Nitrogen.	Carbon Dioxide.
		Per cent.	Per cent.	Per cent	Per cent.	Per cent.	Per cent.
1	B	9.42	90.48	0.10	8.50	90.90	0.60
2	C	9.25	90.65	0.10	.....	.....	.....
3	A	7.65	92.25	0.10	7.55	92.05	0.40
4	C	7.83	92.07	0.10	.....	.....	.....
5	A and C	7.10	92.80	0.10	.....	.....	.....

REMARKS.

Test 1.—The canary, *B*, showed immediate distress as evinced by rapid breathing, open bill, and unsteadiness. In ten minutes' time the bird was apparently in normal condition, with the exception of slight increase in the rate of breathing. It was removed from the atmosphere at the end of one hour's time.

Test 2.—The behavior of the canary, *C*, was similar to that of the bird in the previous experiment.

Test 3.—The canary, *A*, showed immediate distress by panting and unsteadiness, but did not collapse or evince any more distress than the bird in test No. 1. It was left in the atmosphere for one hour.

Test 4.—The canary, *C*, collapsed as soon as it was placed in the atmosphere. It breathed very slowly with eyes and bill closed, but recovered its normal state in less than a minute after it was removed to fresh air.

Test 5.—One canary, *A*, showed distress but did not collapse in twenty minutes' time. Another canary *C*, was placed in the atmosphere and immediately collapsed.

The canaries showed some distress in atmospheres containing 9.4 per cent of oxygen, more pronounced distress in atmospheres containing as low as 7.6 or 7.8 per cent, and in an atmosphere containing as little as 7.1 per cent of oxygen may or may not collapse.

EFFECT ON MEN OF ATMOSPHERES LOW IN OXYGEN.

In a test to determine the effects on man of atmospheres low in oxygen, described in Technical Paper, 122, a member of the Bureau of Mines breathed air in and out of a bag having a capacity of about 70.0 liters, the exhaled carbon dioxide being removed by means of a can of caustic potash inserted between his mouth and the bag, and was rendered unconscious when the oxygen content of the air had fallen to about 7.0 per cent. The mode of action of the "oxygen want" is instructive. The subject felt warning symptoms previous to collapse, but did not believe himself in any danger of losing consciousness, and, in fact, wanted to continue the experiment. He felt no real distress until some time after the experiment, but on the next day was decidedly unwell.

In its insidious action "oxygen want" acts as carbon monoxide frequently does, that is, when the oxygen is slowly decreased. One difficulty in comparing the mode of action of the two lies in the scarcity of experimental data on the effects on men of atmospheres low in oxygen.

Some light is thrown on the action of low-oxygen atmospheres by an accident that occurred in the Lodge Mill colliery, Huddersfield, England[2], in which three men were overcome by black damp in an unused part of the mine. Two men, *A* and *B*, were overcome by the black damp at 3:30 A. M. A third man, *C*, was overcome at 4 A. M. in an attempt to rescue his comrades. At 1 P. M. of the same day rescuers equipped with breathing apparatus removed *C*, and about an hour later removed *A*. A little later *B* was found dead. Both *C* and *A* were in a critical condition, but still breathing. *A* died three days later. The air in which the men were overcome was high in methane and correspondingly low in oxygen.

[2] See Lloyd, W. D., The use of rescue apparatus at Lodge Mill colliery, Huddersfield; with a note by J. S. Haldane: Coll. Guard., November 7th, 1913, vol. 106, pp. 957-955.

Haldane[3] comments on this disaster as follows:

"All the facts recorded indicate that the men were overcome by the insufficiency in the oxygen percentage of the air. There was no reason to suspect the presence of carbon monoxide as there was no gob fire or heating. In addition, the blood of the dead man was black, not red, as it would have been if death was due to carbon monoxide. It is probable that sufficient fire damp was present to reduce the oxygen to 7 or 8 per cent. The fact that *A* did not recover was due to exactly the same cause which often prevents men recovering after severe carbon-monoxide poisoning. The tissues have been severely damaged by the prolonged exposure to dearth of oxygen, so that although the oxygen supply is completely restored recovery is doubtful. In the case of *A*, the post-mortem examination revealed the fact that the heart was dilated. Probably the heart muscles and the other tissues were in a condition of fatty degeneration caused by the want of oxygen. The writer has seen other similar cases of dilation simulating severe heart disease, and only slowly recovering, after prolonged exposure to carbon-monoxide poisoning. So far as he is aware, however, this is the only recorded case of death after partial recovery from exposure to an atmosphere which was simply deficient in oxygen, apart from the presence of carbon monoxide."

In regard to the oxygen deficiency required to cause distress in men, Haldane[4] says:

"When the oxygen content of the air is gradually reduced by the absorption of the oxygen or (what is exactly the same thing) by addition of nitrogen, very little may be felt before the occurence of impairment of the senses and loss of power over the limbs. If the reduction is gradual and the symptoms be carefully watched it will be noticed that at about 12 per cent oxygen—that is with a reduction of 9 per cent—the respirations become just perceptibly deeper. At 10 per cent the respirations are distinctly deeper and more frequent, and the lips become slightly bluish. At 8 per cent the face begins to assume a leaden color, though the distress is still not great. With 5 or 6 per cent there is marked panting, and this is accompanied by clouding of the senses and loss of power over the limbs, which would probably end sooner or later in death. It is probable that any sudden exertion made in air markedly deficient in oxygen may lead to temporary loss of consciousness, so that sudden efforts should be avoided in all cases where, through accident or necessity, a man is in an atmosphere which will not support light and in such a position that he might fall into worse air or otherwise injure himself. When air containing less than 1 or 2 per cent of oxygen is breathed, loss of consciousness, without any distinct warning symptoms, occurs within 40 or 50 seconds. Loss of consciousness in air deprived of oxygen is more rapid than in drowning or strangling, since in the former case not only is the supply of fresh oxygen cut off but the oxygen previously in the lungs is rapidly washed out, loss of consciousness is quickly followed by convulsions, which are followed by cessation of the respiration. The heart still continues to beat, in the case of cats and dogs, for from two to eight minutes; in men this period is probably much longer, for it seems to be the general rule that the larger the animal, the longer it resists asphyxiation. So long as the heart is beating, however feebly, animation may be restored by artificial respiration. This may require to be continued for a considerable period, as the after effects of deprivation of oxygen are very serious and the respiratory center may not recover for some time."

The experiments cited show that oxygen deprivation begins to affect men in about the same time it does canaries, and the percentages that cause collapse are not much different. Atmospheres that will cause the animals to collapse vary to a certain extent, and presumably the same is true of men.

EFFECT OF NATURAL GAS ON MEN.

As far as the diluting action of nitrogen and natural gas in lowering the oxygen content of air is concerned, the two are nearly similar in the effects produced on canaries. Possibly the same is true as regards man, but to make certain of this point, experiments would have to be made on human subjects. One is safe, however, in drawing the conclusion that a large proportion of natural gas in mixture with air is required to affect man and that the danger of death to the occupants of a room because of natural gas escaping from an open gas jet is remote, because of the very large quantity of gas required. An ordinary natural-gas burner in a house, used for giving light, burns about 4 cubic feet per hour. At this rate, to reduce the proportion of oxygen in the air of a room 9 feet high and 15 feet square to 10 per cent, the burner would have to flow gas for about 263 hours, assuming that no gas leaked out of the room through the door jambs, window jambs, and cracks in the walls (an impossibly tight condition, by the way). Therefore the possibility of suffocation being produced by natural gas under such conditions is very remote. Of course, in a small room where several burners were flowing the danger would be greater. The danger of explosion from the accidental lighting of a mixture of natural gas and air is much greater than that of suffocation from it. The proportion of natural gas in air required to make the mixture explosive is about 5 to 12 per cent, whereas to produce suffocation apparently requires about 60 per cent.

Artificial illuminating gas made from coal, on the other hand, may be poisonous when as little as 1 per cent (based on only 10 per cent of carbon monoxide in the gas) of it is in the room, and dangerously so when 2 per cent is present. It is also explosive in relatively small proportion, the low limit being about 7 or 9 per cent and the high limit 18 to 21 per cent.

No account is taken in the foregoing of the imperfect combustion of gas, either natural or artificial, in poorly constructed gas stoves. The danger in such cases from either gas is great, and not only should stoves be well constructed, so that perfect combustion takes place, but every stove should be equipped with a vent leading to the house chimney to take away the products of combustion. Although the results to the occupants of the house if this is not done may not be apparent, in that distress is not produced, yet bad effects may develop, due principally to generation of small proportions of carbon monoxide.—*Technical Paper* 109, *Bureau of Mines.*

[3] Haldane, J. S. Note on paper by W. D. Lloyd: Coll. Guard., vol. 106, 1913, p .958.

[4] Haldane, J. S., The causes of deaths in colliery explosions and underground fires: Report to the Secretary of State for the Home Department, 1896, p. 15.

Superheated Steam Engines

By E. R. Pearce

To what is the high efficiency of the locomobile mainly due? Some are under the impression that it is due to there being practically no steam pipe between the engine and boiler to cause radiation and condensation. This opinion does not appear to carry much weight when one considers that there are many independent engines working with the steam conditions at the cylinder, both as to temperature and dryness, the same as on the locomobile and yet not having anything like its high efficiency.

In the locomobiles the engines are of the piston-valve type, identical in all respects except for a few minor details. Some of these sets, as built by Wolf and Garrett, have the high- and the low-pressure cylinders placed on the boiler at the firebox end, side by side, and are simply jacketed with live steam at boiler temperature, so that any flow of heat through the high-pressure cylinder walls due to the superheat is not lost, but is taken up by the jacketing steam, eventually passing back into the engine.

That which appears to be the biggest factor in securing high economy is the resuperheating of the steam between the cylinders. There seems to be very little difference in the results obtained whether the cylinders are arranged as mentioned, and steam jacketed, or in tandem, with the high-pressure cylinder jacketed by flue gases. This alone tends to point to the gain being derived in the reheating, thereby preventing condensation in the low-pressure cylinder, which is undoubtedly responsible for the bad performances given by many well-designed engines.

On the smaller sizes there is no reheater, the low-pressure cylinder being jacketed with live steam. Usually, these are very efficient, but do not come up to those having reheating. In the latter type the consumption shows marked reduction as the superheats increase, which, in the case of a Wolf engine of the tandem type rated at 60 hp., is as follows:

I	
Temperature of saturated steam	190.9C
Temperature of steam entering the high-pressure cylinder	340.0C
Temperature of steam entering the low-pressure cylinder	171.0C
Superheat entering the high-pressure cylinder	151.9C
Superheat entering the low-pressure cylinder.	57.9C
Steam consumption at 43.2 b.hp.	10.9 lb.

II	
Temperature of saturated steam	190.9C
Temperature of steam entering the high-pressure cylinder	360.0C
Temperature of steam entering the low-pressure cylinder	191.0C
Superheat entering the high-pressure cylinder	172.9C
Superheat entering the low-pressure cylinder	71.4C
Steam consumption at 55 b.hp.	10.29 lb.

The difference in the two cases is undoubtedly due more to the increased superheat than to the heavier load, as after the half-load point has been reached, the consumption is nearly constant. Like the locomotive, the greater part of the evaporation takes place at the firebox, but averages about 4lb. per sq. ft. for the total heating surface. This type of boiler has two other strong points in its favor—there is no chance of leaky brickwork, and the end plates and tubes being removable for cleaning purposes, all parts are easily examined and kept in order.

The question now arises as to whether like results could not be obtained on well-designed existing engines by introducing a reheater between the high- and low-pressure cylinders and carefully lagging them, assuming that the gain in efficiency would warrant the expenditure. —From *Power.*

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, NOVEMBER, 6th, 1915

Published weekly by Munn & Company, Incorporated

Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer; all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

Copyright 1915 by Munn & Co., Inc.

The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00

Scientific American (established 1845) . . . . " 3.00

The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application
Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 233 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

Back Numbers of the Scientific American Supplement

SUPPLEMENTS bearing a date earlier than January 3rd, 1914, can be supplied by the H. W. Wilson Company, 39 Mamaroneck Avenue, White Plains, N. Y. Please order such back numbers from the Wilson Company. Supplements for January 3rd, 1914, and subsequent issues can be supplied at 10 cents each by Munn & Co., Inc., 233 Broadway, New York.

WE wish to call attention to the fact that we are in a position to render competent services in every branch of patent or trade-mark work. Our staff is composed of mechanical, electrical and chemical experts, thoroughly trained to prepare and prosecute all patent applications, irrespective of the complex nature of the subject matter involved, or of the specialized, technical, or scientific knowledge required therefor.

We also have associates throughout the world, who assist in the prosecution of patent and trade-mark applications filed in all countries foreign to the United States.

MUNN & Co.,
Patent Solicitors,
233 Broadway,
New York, N. Y.

Branch Office:
625 F Street, N. W.
Washington, D. C.

Table of Contents

	PAGE
Weights of Elements.—By John Waddell	290
Accuracy of Fire	291
New Types of Films	291
Some Aids to Designing.—8 illustrations	292
French Field Telephones—4 illustrations	293
Submarines that Crossed the Ocean.—1 illustration	293
Amorphous Boron and Magnesium Boride	293
Heredity and Eugenics	293
Applied Chemistry.—By Dr. L. H. Baekeland	294
Torres and His Remarkable Automatic Devices.—7 illustrations	296
The Steel Industry and a Year of War	298
The Sidereal Universe.—II.—By J. S. Plaskett	299
A Comparison of Steam and Electric Locomotives	299
A District Sanitary Disposal Plant.—By Flora Spiegelburg.—3 illustrations	300
Myrtle Wax of Commerce	301
Recent Studies in the Dynamics of Living Matter	301
Commercial Glucose.—By George W. Rolfe	302
Physiological Effect of Natural Gas	303
Superheated Steam Engines.—By E. R. Pearce	304